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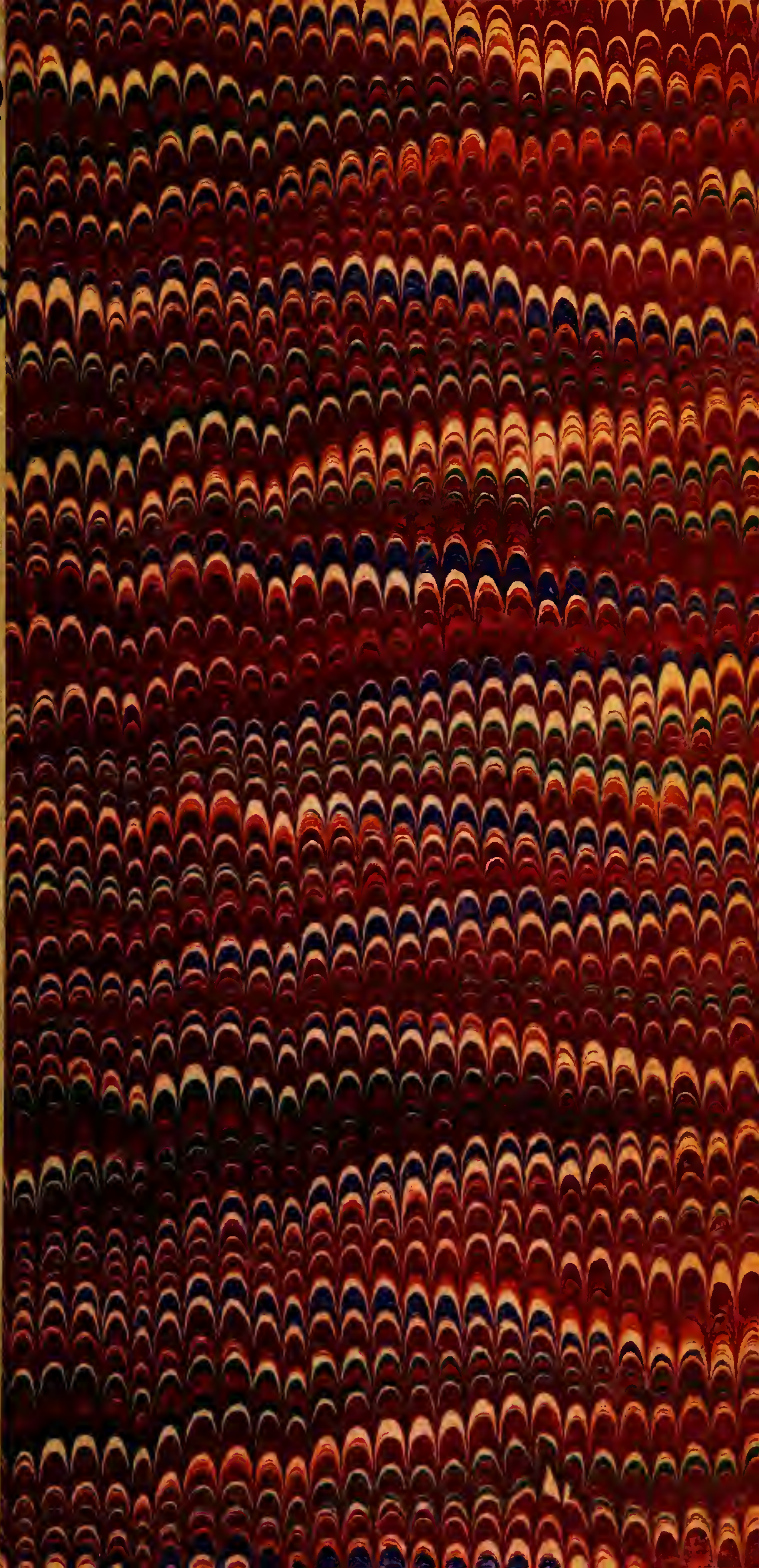

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MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF
THE COUNTRY BETWEEN
YORK AND HULL.

(EXPLANATION OF QUARTER-SHEETS 93 S.E., 94 S.W., AND PART OF 86.)

BY

J. R. DAKYNS, M.A.,
C. FOX-STRANGWAYS, F.G.S.,
AND A. G. CAMERON.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

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(EXPLANATION OF QUARTER-SHEETS 93 S.E., 94 S.W.,
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PREFACE.

From the general simplicity of Geological structure in the tracts embraced in Quarter-Sheets 93 S.E. and 94 S.W. of the Geological Survey Map of England and Wales, it has been decided to describe the whole in one Memoir, together with that part of the ground lying north of the Humber, represented in Sheet 86. The region thus united contains about 530 square miles of the south-east of Yorkshire. Its western and largest portion lies in the great plain of York; its central part is formed by the southern prolongation of the range of chalk hills known as the Wolds; while its eastern part merges into the low grounds of Holderness and the plain of the Humber.

The Geological formations represented in this region range from the Trias to the Upper Chalk, and include a series of glacial and post-glacial deposits. The Triassic sandstones are of importance in the district as water-bearing strata; but they are so generally concealed under superficial deposits that they only appear at the surface in occasional small patches, and most of the information regarding them has been obtained from borings and sinkings for water. The Oolites of this district present features of considerable interest. They are separated from the main Oolitic area of Yorkshire by the uprise of the Lower Lias upon which the Chalk directly rests, and they approach in character rather the Lincolnshire than the Yorkshire type.

Little of the solid rocks can be seen throughout the district owing to the wide extent of the various superficial accumulations. Hence, although it has been thought desirable to prepare an Edition of the south-eastern quarter of Sheet 93 without the Drifts, for the sake of completing the version of this Sheet which represents the "solid geology," it is the Drift Edition which will be found of most service in the field. Some of the clay and sand, mapped as "Warp," may not improbably prove to be of glacial age.

Arch. Geikie,
Director-General.

1st November 1886.

NOTICE.

THE Wold district, together with the eastern part of the area described in the following Memoir, was mapped by MR. DAKYNS, the central Oolitic area and the Chalk escarpment by MR. FOX-STRANGWAYS, the western (Triassic) part with overlying Drift by MR. CAMERON, who also mapped some of the flat land near Hull. MR. REID assisted in mapping some small areas comprised in the eastern half of Sheet 94 S.W.

The whole of the area was surveyed under the superintendence of MR. HOWELL, as District Surveyor.

Each surveyor has supplied notes of the areas he examined, and the whole Memoir has been edited by MR. FOX-STRANGWAYS.

The Six-inch Geological Survey Maps included within this area are not published; but M.S. Coloured Copies are deposited in the Geological Survey Office.

The Geological structure of the Oolitic area is illustrated in detail by Horizontal Section, Sheet 139.

H. W. BRISTOW,
Senior Director.

Geological Survey Office,
28, Jermyn Street, S.W.,
20th October 1886.

CONTENTS.

	Page
PREFACE by the Director-General	iii
PREFACE by the Director	iv

CHAPTER I.

INTRODUCTION	1
Table of Formations	2

CHAPTER II.

TRIAS AND RHÆTIC.

Bunter Sandstone	3
Keuper Sandstone	4
Keuper Marl	8
Rhætic Beds	10

CHAPTER III.

THE LIAS.

Lower Lias	12
Middle Lias	13
Upper Lias	16

CHAPTER IV.

OOLITES.

Lower Oolite:	
Lower Estuarine Series, with Hydraulic Limestone	19
Millepore or Cave Oolite	20
Great Oolite Clay	22
Middle and Upper Oolite:	
Kellaways Rock	22
Oxford and Kimeridge Clays	25

CHAPTER V.

CRETACEOUS ROCKS.

Red Chalk	27
Lower Chalk (Grey Chalk, or Chalk without Flints)	29
Middle Chalk (Chalk with Flints)	30
Upper Chalk (Chalk without Flints)	30

CHAPTER VI.

SUPERFICIAL DEPOSITS.

Page
Boulder Clay, Sand and Gravel - - - 31
Chalk Gravel, capping hills - - 34
Gravel of Dry Chalk Valleys - - - - - 34
Warp and Lacustrine Clay, Sand, and Gravel - - 35
Alluvium, Modern Warp, and Peat - - - 38
Blown Sand - - - - - 39

CHAPTER VII.

PHYSICAL STRUCTURE.

Lie of the Rocks, Faults, &c. - - - - - - 40

APPENDIX I.—Well Sections 42
APPENDIX II.—List of Works on the District - - - 47

LIST OF ILLUSTRATIONS.

Fig. 1. Diagram showing extension of Middle Lias feature by Chalky Gravel at Everthorpe - - 33
Fig. 2. Section in Chalk Valley Gravel, Railway Cutting near Goodmanham Lodge; Market Weighton and Beverley Railway 34
Fig. 3. Section, near Stillingfleet, showing rolling Warp upon Boulder Drift - - - 36
Fig. 4. Sketch Map, showing the thickness of Superficial Beds S.E. of York - - - - - - - 37
Fig. 5. Sketch of the Humber Shore at Melton, showing peat with stumps of trees - - - - - 38

THE GEOLOGY OF

THE COUNTRY BETWEEN YORK AND HULL.

CHAPTER I.

INTRODUCTION.

It is intended in these few pages to describe the geology of the country to the south-east of York, including the district lying between that city and the Humber as far as Hull.

As, on account of the great monotony of some of the formations, there is not much to be said about them, the whole of this district, which includes the one-inch Quarter-Sheets 93 S.E. and 94 S.W., and as much of 86 as lies between them and the Humber, has been taken together.

The area contains about 530 square miles, and consists of three principal physical divisions. The great plain which stretches away in a south-easterly direction from York to the Humber forms the western part, while to the east we have the low land to the north and west of Hull, and between these two the southern part of the range of hills known as the Chalk Wolds.

The first of these, which is part of the great central plain of Yorkshire, comprises more than half the area we have to describe. It consists throughout of a level or slightly undulating country, seldom rising above the 50-foot contour. It is drained by the sluggish streams of the Ouse and Derwent, which fall into the estuary of the Humber, and are tidal throughout a great part of this district.

The second area, which includes the low country in the east of 94 S.W., is a part of the great Holderness flat, and is described more fully in a special Memoir on that district. It also consists of level or slightly undulating country, most of which is below the 25-foot contour, and is drained by the river Hull; the district forming, in fact, the greater part of the basin of that river.

The central area, which comprises the range of the Chalk Wolds, rises in the extreme north-west of the district to over 650 feet, and maintains a considerable elevation all along its western scarp; but declines gradually to the east to join the great plain of Holderness. The greater part of this area, from the porous nature of the rocks, has no perennial surface streams; but on the western side, where the Chalk has been cut through to the beds below, copious springs burst out in all the valleys which indent the line of the escarpment. On the eastern side also, as far as the Boulder Clay has swept up, small streams usually commence to run as soon as that formation is thick enough to bear up the water.

Besides the cities of York and Hull, which are situated at the two extreme corners of the district, the principal towns are Beverley, Market Weighton, Pocklington, Selby, and Goole; there are also a large number of villages.

The rocks coming to the surface or reached in boreholes in this district comprise a large group of strata, containing beds of the age of the Trias, Lias, Oolite, and Chalk, as well as a large area of Glacial and Post-glacial beds; the following being the formations described in this Memoir:—

TABLE OF FORMATIONS.

Post Tertiary.	Recent and Post-glacial.	Blown Sand. Alluvium, Modern Warp and Peat. Warp and Lacustrine Clay. Sand and Gravel. Gravel of Dry Chalk Valleys. Chalk Gravel (capping hills), and Gravel Terraces.
	Glacial	Sand and Gravel. Boulder Clay.
Secondary.	Upper Cretaceous	Upper Chalk (Soft Chalk without Flints). Middle Chalk (Chalk with Flints). Lower Chalk (Grey Chalk without Flints). Red Chalk.
	Upper and Middle Oolite.	Kimeridge Clay. Oxford Clay. Kellaways Rock.
	Lower Oolite	Great Oolite Clay. Millepore or Cave Oolite. Estuarine Series with Hydraulic Limestone.
	Lias	Upper Lias. Middle Lias. Lower Lias.
	Rhætic Beds	Penarth Beds.
	Trias	Keuper Marl. Keuper Sandstone.* Bunter Sandstone.

---

* The Keuper Sandstone is, within the area of this Map, entirely covered by drift, and is known only by borings.

CHAPTER II.

TRIAS AND RHÆTIC.

TRIAS.

The Trias to the south of York may probably be divided into the two groups Bunter and Keuper; the former of these consisting only of sandstone, the latter being further sub-divided into sandstone and marls. Owing to the thick covering of glacial and post-glacial deposits, however, the beds are only seen at a few places, which are mostly beyond the present area, so that the chief evidence to be obtained is from boreholes, and these do not allow very accurate boundaries to be drawn between the sub-divisions.[*]

Bunter Sandstone.—The Bunter Sandstone does not come to the surface anywhere in this district, although it is exposed just to the west about Bilborough, Healaugh, and Long Marston, and is also seen just beyond the southern edge of the Map, where it forms the conspicuous hill of Brayton Barf, rather more than a mile to the south-west of Selby.

From these sections the rock appears to consist of soft brick-red thick-bedded sandstone, with thin marly partings, and occasionally veins of opaque white quartz.

The following boreholes and wells have been sunk into this formation.

Well at Naburn Railway Station.

		Ft.	In.
Drift, 47 ft.	Sand	11	0
	Clay	30	0
	Sand	6	0
Grey sandstone		67	0
	Total	114	0

Well at Cawood Steam Flour Mill. P[†]

		Ft.	In.
Drift, 94 ft.	Sand	3	0
	Clay	57	0
	Quicksand	30	0
	Red Sand	4	0
Soft grey Sandstone		240	0
	Total	334	0

---

[*] Fig. 4, p. 37, shows the positions of the chief boreholes and the thickness of the drift-covering.

[†] Dr. Franklin Parsons has written two papers on the Alluvial Strata and Trias of this district; in these he gives a valuable collection of boreholes, from which those marked P are copied.—*Proc. Yorkshire Geol. Soc.*, vol. vi., p. 214, 1877, and vol. vii. p. 154, 1879.

The water in this well is said to have fallen considerably at the same time that the Selby well gave an overwhelming supply.

Well at Osgodby.

		Ft.	In.
Drift, 25 ft.	Loamy soil	2	0
	Clay	4	0
	Sand	4	0
	Clay	15	0
Red Sandstone		175	0
Total		200	0

*Well at Selby Waterworks.**

		Ft.	In.
Drift, 67 ft. 6 in.	Warpy clay	10	0
	Strong clay	10	6
	Sand and clay	14	8
	Strong clay	7	10
	Clay and silt	8	9
	Grey sand or coarse water sand	7	9
	Red sand	6	6
	Indurated sand	1	6
Red Sandstone		54	6
Red clay and Fuller's earth with pipe clay		8	6
Red Sandstone		203	0
Total		333	6

243,000 gallons pumped every 24 hours without apparently diminishing the quantity. The water is hard, as if from Magnesian Limestone.

Keuper Sandstone.—The Keuper Sandstone occupies a broad belt of country to the east of York and Selby. It is everywhere covered by superficial deposits, but was reached in a boring at Ellerton, near the Derwent, where the section was—

	Ft.	In.
Superficial beds	50	0
White and yellow Sandstone	77	0
Total	127	0

A little to the north of this area at Stamford Bridge, the rock, which is here a hard greenish quartzose sandstone with dark specks, is exposed in the bed of the Derwent; and a deep boring at Strensall showed that this formation is composed mainly of thick beds of white and greenish sandstone with marly partings.*

---

* At the other end of the town there is another well, 380 feet deep, still in red sandstone. Water stands very near the top. At 16 feet from the surface were found trees, nuts, and leaves.

This sandstone appears also to have been reached in a deep boring at Reedness, which was put down in search of coal, at a depth of 342 feet; and the various borings at Goole seem to show that the junction of the sandstone and the marls above runs through the town, those on the west side being in sandstone while those on the east penetrate the marls.

The Keuper Sandstone in the neighbourhood of the Ouse has been reached in the following borings, except those at the Railway Bridge and at Gleadow's Buildings, which reached the marl but did not go through it.

Well at Barmby Ridge, on the Hull and Barnsley Railway.

		Ft.	In.
Drift, 92 ft.	Yellow sand	15	0
	Clay	77	0
Grey sandstone with water		4	0
Total		96	0

Trial Boring for Waterworks, Booth Ferry Road, Goole.†

		Ft.	In.
Drift, 28 ft.	Warpy sand	4	4
	Warpy clay	0	6
	Peat	0	6
	Fine stiff clay	6	8
	Red clay	5	0
	Rough gravel	8	0
	Warp clay	3	0
Red sand		6	0
Hard coarse light red sand		24	0
Red marl		10	0
Hard sand		11	0
Red marl		3	0
Hard sand		26	0
Red marl		1	0
Hard sand		61	0
Red marl		3	0
Hard coarse Sandstone, with small pebbles		3	0
Red sand and marl mixed		84	0
Red sand		22	0
Stiff red marl		2	2
Marl and red sand		22	1
Red sandy marl		59	9
Total		366	0

---

* See Memoirs of the Geological Survey. Explanation of Quarter Sheet, 93 N.E., p. 4.

† At the Windmill shown on the One-Inch Map.

*Artesian Well, Pemberton's Brewery, Goole.*P[*]

		Ft.	In.
Drift, 75 ft.	Top sand	4	0
	Peat	2	0
	Clay	22	0
	Gravel	7	0
	Red clay	5	0
	Sand	6	0
	Hard sand	10	0
	Gravel and sand	9	0
	Clay and cobbles	10	0
Red Sandstone		125	0
	Total	200	0

*Well in George Street, Old Goole.*P

		Ft.	In.
Drift, 33 ft.	Warp	4	0
	Quicksand	1	0
	Peat	1	0
	Quicksand	7	0
	Strong blue clay	20	0
Sand, bluish, then rusty, then red		30	0
	Total	63	0

The following sections, which are further east than the foregoing, appear to have reached the Keuper Marl, but did not go through it, except those at Reedness and Saltmarshe.

*Section in foundations of Bridge over River Ouse, on Hull and Doncaster Branch of North-Eastern Railway.*P

		Ft.	In.	
Drift, 35 ft. 6 in.	Bottom of river, about	16	0	below surface.
	River mud	1	6	
	Peat	7	6	
	Sand and gravel	3	0	
	Clay	1	6	
	Sand and gravel	4	6	
	Soft clay	1	6	
Soft blue shale		12	0	
Strong blue shale with gypsum		3	6	
	Total	51	0	

*Well at Gleadow's Buildings, Old Goole.*P

		Ft.	In.
Drift, 45 ft. 3 in.	Old well	10	0
	Quicksand	11	0
	Laminated clay	13	0
	Stiff sandy warp	11	0
	Gravel (rounded chert pebbles)	0	3
Blue and red marl		9	9
	Total	55	0

---

[*] Near the River Ouse.

Boring at Goole in connexion with a railway bridge across the Ouse.[*]

		Ft.	In.
Drift, 56 ft.	Silt and sand	20	0
	Black peat	18	0
	Soft brown clay, sand, and gravel	18	0
Soft blue shale (full of water)		18	0
Strong blue shale with gypsum		30	0
	Total	104	0

Saltmarshe, sinking and boring.[†]

		Ft.	In.
Drift, 54 ft.	Earth	36	0
	Quicksand	18	0
White and blue plaster and red marl		126	0
Blue marl		33	0
Red marl		42	0
Soft red sandstone		60	0
	Total	315	0

Borehole at Reedness.

		Ft.	In.
Drift, 69 ft. 8 in.	Dark soil	1	6
	Yellow sandy warp	3	3
	Dark blue warp	4	6
	Fine blue warp	6	0
	Blue sandy warp	6	0
	Light grey sand, with water	9	0
	Black moor earth with rotten wood	11	9
	Strong blue clay	3	3
	Grey sand, with water	0	9
	Black gravel and quicksand, very sharp	10	3
	Red sand	1	5
	Grey sand and gravel	5	4
	Red sand	3	4
	Gravel and sharp sand	3	4
Red marl with grey specks		3	2
Red sandstone with alabaster and some thin hard lists		8	1
Strong blue stone with thin white beds		9	2
Dark red bind with white beds of alabaster		18	3
Strong blue stone		1	8
Red bind with thin beds of blue stone		10	3
Blue stone		4	10
Red bind with thin white beds and hard lists of blue stone		8	6
Blue bind		2	0
Red bind with thin hard lists of blue stone and thin beds of alabaster		7	7
Red stone		8	8
Red bind with hard lists of stone and white alabaster		16	10
Blue stone		4	4

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[*] It is doubtful whether this is the same section as that given by Dr. Parsons. It may have been a preliminary boring near the site of the bridge.

[†] From account supplied by Mr. Clarke, Knedlington, near Howden.

	Ft.	In.
Red bind with thin beds of alabaster	17	11
Blue bind	1	9
Red bind with thin beds of alabaster	6	8
Blue stone and white parting	0	2
Red stone and blue lists in it	19	8
Red bind with thin beds of alabaster	22	6
Red stone	5	6
Blue stone	4	0
Red bind with hard lists of stone and white partings	6	6
Red stone with thin white partings	5	6
Blue stone thin beds and blue bind partings	6	6
Blue bind with thin beds of blue stone	16	6
Red bind with thin beds of alabaster	11	0
Blue bind with soft beds of alabaster	8	3
Dark soft red bind	32	5
Blue stone	4	0
Red sandstone, soft at top and gets harder lower down	169	6
Red bind	2	0
Red sandstone	16	6
Red bind with lists of blue stone	3	6
Red sandstone	233	6
Red bind with bright shining specks	3	2
Dark red bind	2	10
Red sandstone	11	6
Dark red bind	1	0
Red sandstone	19	6
Red bind	2	3
Red stone	74	3
Red bind	1	0
Red stone	24	6
Soft red bind	3	10
Red sandstone	20	2
Dark red bind	1	0
Red sandstone	24	0
Dark red bind	1	3
Red sandstone	38	3
Light red sandstone	3	0
Red sandstone	30	8
Total	1,029	0

Keuper Marl.—These marls, as they rise towards the flanks of the hills bounding the great plain on the east, are better seen than the other members of the Trias. They consist of red and grey marl, with beds of gypsum, and a little thin flaggy sandstone, which latter is often covered with pseudomorphous crystals of salt. The western or lower portion of the Keuper Marl is concealed by the deposits of the plain; but as these become thinner towards the edge, the marls gradually appear, and are seen in the several small streams about Barmby-on-the-Moor, Pocklington, Burnby, and Shipton. North of Pocklington, and between that place and Market Weighton, they form part of the rising ground east of the railway, and are exposed at numerous places, particularly in the cuttings near Yapham, south of Burnby, and south of Shipton. The isolated hill of Holme-on-Spalding-Moor, which, rising out of the flat to a height of 150 feet above the sea, forms so conspicuous an object in the landscape, is also composed mainly of these marls. South of this the Keuper Marl does not rise above the plain; but large excavations are frequently made into it for marling the sandy flats of the district. These excavations are vory common as far south as North Cliff, but south of that the superficial deposits are apparently too thick to allow of the marl being worked, and the clay from the Lias bank is more readily obtained for the purpose.

Besides the Reedness and Saltmarshe borings and those on the east side of Goole, the Keuper Marl has been reached in the following wells :—

Well at Melbourne, near Pocklington, 1796.*

		Ft.	In.
Drift, 42 ft. 4 in.	Sandy loam	10	0
	Calc. clay	4	0
	Quicksand	7	0
	Warp	13	0
	Red soapy stone mixed with warp	6	0
	Purple gravel	2	4
	Blue shale	1	6
	Red soapy stone	5	0
	,, mixed with colours	18	0
	White soapy stone	1	0
	Mixed ,,	3	0
	Blue shale	1	0
	Red stone	4	0
	Blue stone mixed with plaster	1	0
	Hard stone	1	6
	Total	78	4

*Well at Bellasize, near Staddlethorpe.*P

		Ft.	In.
Drift, 59 ft. 4 in.	Top soil	1	0
	Sandy warp	1	0
	Laminated clay, with sand on one side	5	0
	Clay, with warp sand	11	0
	Blue clay	12	0
	Grey sand	0	6
	Red marl	10	0
	Blue clay	6	6
	Flint or stone	3	4
	Sand and soft warp, with water	9	0
	Red marl, with gypsum	12	0
	Dark clay, very tough	4	0
	Red marl, with white matter	4	0
	Blueish stone	1	0
	Red marl	5	0
	Grey sharp sand	2	0
	Red bind, very tough	5	0
	Blue bind	2	0
	Red marl, with gypsum	8	0
	Total	102	4

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* From a General View of the Agriculture of the East Riding of York, 8vo. York, 1812, p. 24.

Well at Blacksmith's Arms, Holme.

	Ft.	In.
Drift Sand	15	0
Blue stone	45	0
Layer of "plaster" and some sand.		
"Slate," blue and brown stone	240	0
Total	300	0

Rhætic (Penarth) Beds.

These beds, which consist of black papery shales with green marls at the base, are very poorly seen in this district. Below the Lias at Pocklington green marls are seen; and a little further on, in Kildwick Percy Park, there are dark papery shales with a little thin sandstone and green marl below. Green marl is also seen at the Vicarage, and at a few places along the bank to the south, but the outcrop is much obscured by the slipping down of the Lias beds above.

At Warter Priory, along the woods in the lower part of the park, green marls and dark shales are exposed at several places; green marl and flaggy sandstone have also been turned out from an old excavation near the corner of the wood immediately below the house. Fragments of White Lias limestone are also very abundant round the sides of this valley, so that the outcrop is not difficult to trace.

In Londesbrough Park the green marls are again seen, but there are no exposures of the shales. At Market Weighton the outcrop probably runs through the west part of the town, and can be fairly well fixed by the aid of two wells. The first of these, which is by the side of the road the third of a mile north of the Station, is 52 feet deep, and went through 6 feet of green marl at the bottom. The other, which is just north of the railway about 600 yards west of the Station, is 14 feet deep, and principally in black shale with small shells; and, from green marl being seen close by, must have been in Rhætic Beds. South of the town the outcrop keeps close along the edge of the flat, and some dark shale and green marl are seen between the footpath to Houghton Hall and the road. In the neighbourhood of North Cliff several large pits have been made in the Lias for marling the sandy flats below. The second of these, which is about 600 yards north of the village, is in the lower beds of the Lias; in the bottom of this pit a more recent excavation has been made in finely laminated papery shales, with minute fossils, which are lower than anything else seen in this bank, and must represent part, although probably not quite the lowest beds, of the Rhætic series. The great road-cutting just north of the village also shows, in its lowest part, shales which have a very Rhætic aspect, and the beds above evidently represent quite the base of the Lias.

The following section was measured in the lower part of this road:—

Section in road cutting North Cliff.

	Ft.	In.
Thick bands of limestone, with *Ostrea liassica*, *Lima*, &c.	4	0
Clay	2	0
Hard blue shelly bed, weathering white, with *Myacites*, *Pleuromya crowcombeia*	0	3
Shale, with sandy bands	8 0 to 10	0
Band of fine-grained sandstone	0	8
Brown shale	1	0
Shale	6	0 or more.

From these sections it appears that the Rhætic Beds crop out at the villages of North and South Cliff, just along the edge of the sands; but further south there is no evidence of their presence, although they cannot be far away from the Lias feature till this sinks beneath the flat to the south of Cave.

CHAPTER III.

THE LIAS.

The Lias makes a bank or terrace at the foot of the rising ground formed by the Oolite hills and the Chalk Wolds. In the north of the district, owing to the overlap of the Chalk, only the lower part of the formation occurs; but as we trace the beds southwards the upper part gradually comes in, and continues as a narrow band parallel with the base of the Oolite till it finally disappears beneath the sands and alluvium of the Humber.

Lower Lias.—The lithological character of the Lower Lias has considerably changed from what it was in the northern part of the county; and instead of consisting principally of shales with thin calcareous bands and ferruginous nodules, the beds here are much more calcareous, and contain, especially in the lower part, strong bands of fossiliferous limestone. These hard bands cause the lower beds to stand out in a bold feature, which forms a fine terrace, both at Pocklington and Market Weighton. South of the latter town in the vicinity of North Cliff these beds, as we have mentioned, have been largely worked for marling the land below, and it is here that we are best able to study their character. There are about half a dozen or more of these pits, a very detailed account of which has been given by Prof. Blake.* In a general way the beds here exposed may be described as consisting of a thick bed of limestone at the top, full of *Lima gigantea, Cardinia Listeri,* and *Ammonites Johnstoni;* below this are softer beds, not generally so well seen, and then beds of limestone again very full of *Ostrea,* forming regular oyster beds; below which there are more shales and soft beds with thin limestones, the lowest beds being full of *Pleuromya crowcombeia* and *Modiola minima;* and below this again more shales with brown sandy bands and fine-grained white limestone resting on the dark laminated shales of the Rhætic. The higher beds of the Lower Lias are not nearly so well exposed as the lower portion, but there are several clay-pits in which these beds are seen, more particularly about Hotham and near Warter. Between the former place and Houghton the "marl" pits are very numerous, the clay containing *Gryphæa incurva* in great abundance. The total thickness of the Lower Lias is about 100 or 150 feet, but a great portion of the upper beds is frequently hidden by the overlap of the Chalk, so that very often not more than half this thickness is seen at the outcrop. In the steep bank at Cliff there are nearly 100 feet of these beds, the remaining portion forming the great spread between this place and Newbald.

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* Quart. Journ. Geol. Soc., vol. xxviii., p. 132, 1872; and the Yorkshire Lias, p. 38.

To the north-east of Pocklington the Lower Lias forms the sharp projecting feature just above the town, and is well exposed on the brow of the hill; but the upper part is hidden by a great quantity of chalk débris,* extending over the surface between Wood House and Kildwick Percy Hall.

Along the steep bank by Denison's Wood the beds are well seen, although much slipped; and passing round into the Warter Valley, we have the section at the brickyard showing beds high in the series,† while in the stream below Warter Priory there is a good section in the basement beds of the formation.

South of Nunburnholme the Lower Lias makes a good feature to the east of the railway, but there being a thin covering of drift here, is not well seen till a little beyond Cleaving Grange, where it is thrown up by a fault, and is exposed in the bank below the road.

In the two valleys running north of Londesbrough Park the Lias extends for some distance, beds low in the series being exposed at Park Farm and elsewhere. In the neighbourhood of Market Weighton the Lias is everywhere well exposed, particularly in the railway cutting and in the beck towards Goodmanham, and also to the south as far as Houghton Hall; beyond this it forms the broad spreading terrace of Houghton Moor, between North Cliff and Newbald, but is much hidden by a great covering of sand, the land being very light, and not having at all a Lias aspect.

The Lower Lias forms the hill to the south of North Cave, where it is exposed in the railway cutting, and the beds may be followed round the hill to South Cave, but beyond this they pass below the alluvial flat, and are not again seen this side of the Humber.

Between North and South Cave the Lower Lias is covered with great quantities of gravel, composed almost entirely of Lias fragments, in which specimens of *Gryphæa incurva* are especially abundant, showing to how great an extent the Lias must have been exposed to denudation, and also how abundant this particular fossil must have been in those beds.

Middle Lias.—The Middle Lias in the northern part of this district consists of thin oolitic ironstone about three feet thick, which is seen at a few places cropping out beneath the Chalk, but further south the thickness increases to eight or nine feet, and contains beds of thin irregular flaggy limestone; further south still it is probably thicker; and, although it must have been passed through in the boring near Brantingham Grange, it is uncertain what beds should be referred to the Middle Lias.

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* See p. 32.

† *Am. armatus* and *Am. Macdonnellii* are mentioned by Tate and Blake from this pit. *Loc. cit.*, p. 86.

The following is the account of this boring as furnished by Mr. T. Allison, Guisborough:—

Section of diamond-drill boring near Mill Hill, between Elloughton and Brantingham Grange.

		Ft.	In.		
Drift, 20 ft. 6 in.	Soil and yellow sand	7	6		
	Yellow clay	13	0		
Calcareous sandstone		2	0		
Blue Cave limestone		27	0		
Dark shale and calcareous bands		26	0		
,, ,,		12	0		
Grey clay shale		14	0		
Brown siliceous stone		1	8	9	8
,, ferruginous stone		5	4		
Blue ,, ,,		2	8		
Blue shale		35	10		
Calcareous ferruginous band		0	7	16	6
Shale with broken shells		2	6		
Calcareous ferruginous band		0	5		
Dark clay shale		7	0		
,, ,, ,, with calcareous ferruginous bands		6	0		
,, ,, ,,		28	0		
Total		192	6		

The Middle Lias is first seen in situ to the south of Nunburnholme, in ditch sections, near Partridge Hall; although fragments of an oolitic rock were observed north of this, just at the base of the Chalk, on the brow of the hill south of Kildwick Percy Wold House, which may be of this age. The fact of the upper part of the Lower Lias being seen at Warter brickyard also rather tends to show that the Middle Lias exists near the base of the Chalk about here. About half a mile south of Partridge Hall the beds are thrown up by a fault, and do not again appear from beneath the Chalk till we get to Goodmanham, where ironstone fragments with *Pecten* are common at the base of the Chalk, although the bed at first is not thick enough to map. *Ammonites spinatus* was also obtained from here. To the south of Goodmanham the bed becomes more distinct, and may be traced round the sides of that valley, there being a section in the road on the south side of the railway which shows,*

	Ft.	In.
Ironstone	1	0
Grey clay	0	6
Ironstone	3	6
Clay		

From this point the outcrop is probably continuous, although not always seen; below Sancton it becomes very distinct, forming quite a terrace to the west of the village. At Cauldwell Spring the rock has rather an unusual appearance, being a dense blue oolitic ironstone, which, on examination under a lens, seems to consist of brown and white oolitic grains cemented by iron. It is very probable that the rock here owes its dark colour to being less oxidized than in other places. It is very fossiliferous, and contains *Ammonites spinatus*, *Pecten* (like *P. vimineus*), &c. South of Saneton the outcrop is somewhat obscured by sands, but it is seen in the road at the boundary of the parish and opposite Newbald Sike, and at a few places on the west side of the road as far as Newbald. Above Hotham and North Cave it again forms a good feature and is well exposed, being cut into by the roads going up the bank east of these places. The rock here is largely made up of brown and grey crystalline limestone, and contains the following fossils:—

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* Compare Tate and Blake, the Yorkshire Lias, p. 143, where a list of characteristic fossils from this place is given.

Rhynchonella tetrahedra.
Terebratula Edwardsii.
" *punctata.*
Avicula inæquivalvis.
Pecten æquivalvis.
" *sublævis.*
Lima.

The railway at Everthorpe gives about the best section of these beds of any in the district. The strata here, which are lying very flat, are exposed in the cutting for a distance of over 200 yards, and consist of ferruginous flaggy limestone, with a very irregular top, much broken by large "pipes"; below are shales, the whole, including the soft beds at the bottom, having a thickness of about 9 feet.* South of here the outcrop curves round through the village of Everthorpe to Castle Farm† and South Cave Church, forming a good terrace to the west of the park. It crosses the lower end of the Fish Pond, being seen in the road below, and may be followed along the bank to Ellerker, where it crops out in the beck passing through the village; beyond this it gets below the level of the sands, but has been cut into by a ditch about three-quarters of a mile to the south, and was also met with in the boring near Brantingham Grange, as mentioned above. This boring is somewhat doubtful, but it is probable that the alternating calcareous and ferruginous bands with beds of shale 16 ft. 6 in., should be referred to the Middle Lias.

From the neighbourhood of Ellerker the following fossils were obtained:—

Rhynchonella tetrahedra.
Terebratula Edwardsii.
" *punctata.*
Belemnites breviformis.

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* Messrs. Keeping and Middlemiss, in describing this section, make the Middle Lias rather thicker, as they include the *Capricornus* beds at the base. *Geol. Mag.*, dec. ii., vol. x., p. 216.

† There are two places of this name. The text refers to the one at Cave Castle.

The following is an analysis of the ironstone from Cauldwell Spring, near Sancton, kindly made for us by Mr. L. F. Gjers, of Middlesbrough.

Sample dried at 212° :—

Protoxide of iron	24·70
Peroxide of iron	5·20
Protoxide of manganese	0·50
Silica	8·80
Alumina	7·85
Lime	20·50
Magnesia	4·00
Phosphoric acid	0·60
Sulphur	0·90
Combined water	2·40
Carbonic acid	24·50
	99·95

Loss by calcination	27·50
Metallic iron	22·80
Metallic iron in calcined stone	31·45

Upper Lias.—The shales of the Upper Lias form a very narrow band, the outcrop of which follows that of the Middle Lias so closely that the description of one will nearly answer for that of the other. There is a small outcrop of the beds below Partridge Hall; but they are not seen in section, and do not appear again from beneath the Chalk till they leave that formation to the south of Market Weighton.

To the north of Sancton there is a strip of clayey ground between the Middle Lias and the Oolites, which must represent these shales, but they are not seen till south of the village, where, opposite Newbald Sike, is an old clay-pit in which they have been worked. A well here, just at the outcrop of the Red Chalk, is said to be 60 feet deep, and to have gone through 12 feet of limestone at the bottom. This, if it is to be relied upon, would give about 40 feet for the Upper Lias, and it cannot be any more, if so much, at this place.

To the south of this the clays are still very indistinctly seen, but may be followed by the line of slightly heavier ground they make between the other beds.

In Drewton Beck and in the road at Everthorpe a little clay is seen, but it is not till we reach Ellerker that anything like a good section is obtained. In the beck at this village the Middle Lias, as mentioned above, is seen; and above this, at the eastern end, just below the mill, there are dark laminated shales, which may be followed to the base of the Oolite. This being only a ditch-section it is difficult to estimate the thickness, but it will probably be between 20 and 30 feet.

In a limestone quarry, about 700 yards to the south, these beds were reached in a trial-shaft for ironstone, and a large quantity of the shale with *Ammonites serpentinus* was turned out.

The following is the account of this shaft, furnished by Mr. Allison:—

	Ft.	In.
Calcareous soil	1	0
Blue Cave limestone	18	0
Blue marl	8	0
Yellow calcareous marl	3	6
Blue shale with nodules	7	0
Total	37	6

The wellsinker's account slightly differs, but agrees better with the beck section at Ellerker. It was—

	Ft.	In.
Limestone	14	0
Hard stone	2	0
Clay	4	0
Stone	3	0
Clay	6	0
Hard stone	1	0
Black shale	6	0
Total	36	0

From this latter account it would appear that the "Stone 3 ft." is the Hydraulic Limestone, and the "Hard Stone 1 ft." the base of the Oolites.

About here the outcrop of the Lias sinks beneath the sands, and is not again seen, although it has been reached in the several trial-holes for ironstone between here and Brough.

At the point where the footpath to Ellerker crosses Whin Moor Lane, a shaft was sunk 17 feet in sand and blue clay; no particulars of this shaft were kept, but, judging from the outcrop of Middle Lias ironstone near here, it must have nearly gone through the Upper Lias shale; as also probably did the next shaft, which is 400 yards to the south, and gave—

	Ft.	In.
Sandy soil	3	0
Stony clay	1	0
Bottom part of blue Cave Limestone	1	6
Blue shale with nodules of cement stone	17	0
Total	22	6

In this section the "Blue Cave Limestone" represents the Basement Bed of the Oolites, as the site of the shaft is certainly below the base of the Cave Limestone, and very near the base of the Oolites altogether.

The diamond-boring near Brantingham Grange gives 35 ft. 10 in. of blue shale below the Oolite, if we are right in this interpretation of the section. In Brough a boring at the back of the Railway Hotel is said to have reached "Sandstone" at 90 ft., while one at the Station is 18 ft. in clay, and then "Greystone," and one at Castle Hill is 40 ft. to "Stone," but there is so much discrepancy about these Brough borings that they are of little value.

CHAPTER IV.

OOLITES.

LOWER OOLITES.

The Lower Oolites in this district form a continuation of those in Lincolnshire and beyond, and with these they should be compared, rather than with those in the northern part of the county, which, although similar in some respects, undergo considerable alteration during their overlap by the Cretaceous beds.

The great Estuarine Series, which forms so striking a feature in North Yorkshire, has almost entirely disappeared, and the remaining beds, chiefly marine, occupy a narrow strip at the foot of the Wolds southward from Market Weighton, which is never more than about half a mile in breadth.

These beds first appear rather more than a mile to the north of Sancton; they are overlapped by the Chalk in the valley to the south of the village, but appear again about Newbald, and continue thence uninterruptedly to the Humber, where, however, they are a good deal obscured by superficial deposits.

Lower Estuarine Series with Hydraulic Limestone.—These beds, which form the base of the Lower Oolites in this district, are the same as those to which the name "Basement Beds" has been given in Lincolnshire, with which they should be correlated in preference to the Lower Estuarine Series of the Yorkshire coast. They are composed mostly of clays with some shaly sandstone, and at the base a thin fossiliferous sandstone. This latter, which at the most is not more than a few inches thick, may, to a certain extent, represent the Dogger; it is too thin in this district to be mapped separately, in fact it has only been seen at one point. The beck just above the mill at Ellerker gives the entire section from the Hydraulic Limestone to the Lias, and shows how thin these beds are about here. The section is—

	FT.	IN.
Hydraulic Limestone - - - - - -	2	6
Yellow sandy shale - - - - - -	6	0
Calcareous sandstone with fossils -	0	3
Dark shale (Lias) - - - - - -		

The trial shafts south of Ellerker, from the lack of marked lithological divisions, do not give much insight into these beds. It is probable that there are somewhere about 20 feet of measures, more or less, between the Cave Limestone and the Lias.

These Estuarine Beds first crop out from beneath the Chalk between Market Weighton and Sancton, but their presence here can be only inferred. The first indication of them is to the south of the latter place, where the outcrop of the Hydraulic Limestone is seen in a field by the road-side, with clays below and apparently also above.

Between here and Newbald Sike the beds are overlapped by the Chalk, which comes down on the Lias; and although they crop out again along the bank there is no evidence of them as far as Newbald. South of this village the outcrop of the Hydraulic Limestone and the clay above become much clearer, and fragments of the limestone are frequently seen strewn over the fields.

At the side of the road going up the hill east of Hotham, and a little above the Middle Lias section previously mentioned, the limestone, which is three feet thick, has been quarried for mending the roads, and is better exposed than anywhere else in the district. The outcrop still continues clear for some distance to the south, and both the clay and fragments of limestone are seen in the railway and road east of Everthorpe, and about South Cave.

In the stream at Ellerker, as given in the section above, the limestone is 2 ft. 6 in. thick, with 6 ft. of shale below, and then the sandstone at the base, but the beds above are not very clear; it is evident, however, that there is scarcely any thickness of measures, as the Cave Limestone crops out almost immediately above at the windmill, and the trial-holes also show that there is not much difference in the beds.

The Hydraulic Limestone has, therefore, not been carried on as a separate bed south of this point; and the Estuarine Beds themselves, although forming the lower part of the bank between here and Brough, are covered by the superficial sands which sweep up the slope.

The boring near Brantingham Grange apparently went through 14 ft. of these Estuarine Beds, and 9 ft. 8 ins. of harder beds below, which probably represent the Dogger or the Basement Beds of Lincolnshire.*

The Millepore or Cave Oolite.—This, which is the principal and best known of all the Jurassic rocks in this part of the county, consists of a soft white oolite, which is hard and blue-centred when first quarried, but decomposes on exposure to the air, or to water conveying carbonic acid, into a friable oolitic "sand." This is noticeable in many old quarries, particularly near Newbald, where most of the rock, which at one time must have been good limestone, is now a soft oolitic "sand." The upper part of the rock is usually flaggy and false-bedded, as may be seen in the quarries about South Cave, and in the Humber at Brough.

The Limestone, which has a thickness of from 20 to 30 feet, or perhaps rather more, crops out immediately below the Red Chalk

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[*] See p. 14.

to the east of Market Weighton; and, crossing the road north of Mask Hall, continues along the hillside to Sancton, where it has been rather extensively quarried; but these quarries are now filled in, and there being a good deal of superficial sand, the course of the limestone through the village is obscure.

Prof. Blake and others consider that the beds here are faulted, but we could find no evidence of this; and the limestone, although dipping rather strongly to the east, is at about the same level on both sides of the little valley crossing the village.*

At Newbald, where the limestone again comes out from the overlap of the Chalk, it forms a considerable spread, and has been largely quarried to the west of the village.

In the hollow half a mile south of South Newbald the outcrop may be broken by a small fault; but as a slight roll of the beds would cause the little irregularity observed here, we have not shown one. Between here and Cave the limestone again spreads out into a good feature a quarter of a mile or more in breadth. It has been extensively quarried in this district, and a clear section is shown in the railway cutting, from which Messrs. Keeping and Middlemiss mention the following species:—*Trigonia conjungens*, Lyc., *Lima pectiniformis*, Schl., *Hyboclypus*, and *Cricopora straminea*, Phil.†

In a well at the cross roads half a mile north of South Cave, the rock, which is 20 feet thick, was met with at a depth of 49 feet.‡ The outcrop which crosses the Park is rather more obscure, but south of this it again forms a good feature, and may be traced above the village of Ellerker uninterruptedly to within about 400 yards of Brough. In this part of its course the limestone has also been largely quarried, although much covered by superficial gravels, which at Brough itself are of great thickness. The stone from these quarries was used in the construction of the Hull docks, and in earlier times for the monasteries of Holderness. From 14 to 18 feet of limestone were met with in the shaft near Ellerker, of which Mr. Allison gives the following analysis:—

Carbonate of lime	76·40
Silica	18·10
Alumina	2·82
Iron peroxide	1·43
Carbonate of magnesia	1·21
Water	0·06
Total	100·02

In the boring near Brantingham Grange there were nearly 30 feet of limestone, and the cores below this were also excessively calcareous, very much resembling some of the beds seen at the Kirton Tunnel quarry in Lincolnshire, which have been classed with this rock; they are there worked for cement.

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* The Yorkshire Lias, p. 208, and map.
† Geol. Mag., dec. II., vol. x., p. 216.
‡ See p. 22.

The limestone, although entirely hidden at Brough for the space of nearly a mile, appears again in the bed of the Humber, where it forms the reef of rocks known as Brough Scalp.

Great Oolite Clay.—Between the Cave Oolite and the Kellaways Rock are a series of sands and clays which were first considered to be the equivalent of the Upper Estuarine Series of the Yorkshire coast, but as they join on with the Great Oolite Clays of Lincolnshire, they have now been mapped with that formation. These beds have a thickness of from 20 to 30 feet, and consist mostly of sand, clayey in part. They were passed through in the well at the cross roads north of South Cave, of which the following is the complete section :—

*Well at Drewton Stray Cottage.**

	Ft.	In.
Top soil.		
Clayey soil - - - - - -	5	0
Hard red and white sand with large stone boulders -	25	0
Blue shaly clay, in which water lodges - -	3	0
Sand - - - -	16	0
Rock - - - - -	20	0
Very hard blue clay - - -	2	0
Blue shaly clay - - - -	2 0 to 3	0

This clay was bored into from 10 ft. to 12 ft. without reaching the bottom.

The sands which are classed with this formation are first seen at the village of Sancton, where they have been dug. In the pit behind the church the beds are dipping at a high angle, about 12 degrees, thus showing the great unconformity between them and the Chalk which has not nearly so high a dip. In this pit the limestone was met with at 30 feet, and a well at Sancton Grange just above is said to be 90 feet in Chalk and limestone ; but whether the sand was met with is not stated ; if not, the outcrop to the north must terminate very sharply.

The only other place where these beds are well exposed is in the railway cutting east of the road at Drewton. Here the upper part of the formation is seen, but the beds are so similar to the sands of the Kellaways Rock above that it is difficult to fix an exact horizon between them.

The outcrop of these sands and clays forms a narrow band beneath that of the Kellaways Rock, but there is nothing of special interest about it, and it can be best followed in tracing that formation.

MIDDLE AND UPPER OOLITES.

Kellaways Rock.—The Kellaways Rock has a maximum thickness of from 35 to 40 feet, but it becomes thinner towards the south, and cannot be nearly so much as this near the Humber. It consists in the upper part of reddish brown sandstones crowded with *Gryphæa sublŏba* and other fossils. Below this are softer beds of sandrock with two lines of large doggers, and at the base soft sands with lines of *Belemnites.*

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* Supplied by Mr. J. Wilson.

The Kellaways Rock first appears from beneath the Chalk to the north of Newbald, and in a sand-pit at the village the following section occurs :—

Section in Sand-pit, North Newbald.

	Ft.	In.
Reddish soft Sandstone, the lower 2 ft. 2 in. crowded with *Gryphæa bullata, Rhynchonella, Trigonia* - -	4	0
Soft whitish Sandstone - -	9	0
Thin band, full of cast of *Belemnites,* large and small -		
Soft white Sandstone - -	10	0
Hard band, with *Myacites,* &c. - - - -		

From this pit the beds dip rather sharply (8 degrees) towards the village, where they are obscured by the sand and gravel of the valley, but may be traced with ease to the south, being exposed at several places in the fields to the east of the main road. At a distance of rather more than half a mile south of South Newbald the outcrop crosses the road, but is obscured by a thin covering of drift as far as Kettlethorpe, where it again crosses the road, and has been worked at an old sand-pit below the farm, and also at Drewton Manor House. At both these places, although the sections have now fallen in, the siliceous doggers are still very apparent.

The best section, however, in the whole district is that exposed in the railway cutting at Drewton, where the beds, which dip at an angle of 3 degrees to the east, are exposed for a distance of over 400 yards, and show the following section :—

Railway cutting, Drewton.

	Ft.	In.
Dark clay [Oxford] with *Belemnites hastatus, &c.* -	a few feet.	
Hard brown sandy beds with bands of *Gryphæa subloba*	10	0
White and yellow sands with lines of large doggers which weather out from the softer beds - - -	25	0
Brown sandy band with casts of *Belemnites* in great numbers - - -	a few inches.	
White sands more argillaceous than those above -	20	0 or more

Fossils are very abundant in the upper bed of sandstone of which the most common species are*—

Avicula braamburiensis. Phil.
Gryphæa subloba—dilatata. Sow.
Trigonia.
Pinna.
Natica.
Turbo sulcostomus. Phil.
Ammonites Kœnigi. Sow.
,, *sublævis.* Sow.
Belemnites, three species.

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* Messrs. Keeping and Middlemiss give a long list of fossils from here; *Geol. Mag.*, dec. II., vol. x., p. 218.

At the cross roads a little to the south 25 feet of red and white sand with balls were passed through in the well section at Drewton Stray Cottage, which represent the lower part of this formation (*see* p. 22), but the rock is not well exposed between here and South Cave.

At the latter place these beds have been dug for sand, and there is an exposure in a pit at the south end of the village where the sandstone, which contains *Gryphæa bullata* very abundantly, although soft, is sufficiently consolidated to be worked into small caves.

South of this the outcrop passes under the superficial sand and chalk gravel of the lower ground west of Brantingham, but the rock was met with in the trial shaft which was sunk for ironstone at the foot of Woo Dale.* We have obtained two accounts of this shaft, and as there is a slight difference between them we give both.

Shaft in Woodale: account supplied by Mr. R. C. Kingston.

	Ft.	In.
Soil	1	0
Gravel	4	0
Clay shale	23	0
Sulphur pyrites	1	0
Gravel and fossils	0	9
Limestone	4	0
Sand and fossils	4	0
Black shale	25	0
Total	62	9

Shaft in Woodale: account supplied by Mr. T. Allison.

	Ft.	In.
Soil and gravel	5	0
Shaly clay	23	9
Iron pyrites	0	9
Limestone	2	0
White sandy shale	4	0
White friable sandstone, water lodges	6	0
Hard grey sandstone, rather micaceous	2	6
Total	44	0

From this shaft it would appear that there are only about 10 feet of Kellaways Rock here, which, if the information is correct, would show that it thins very rapidly in this direction.

South-west of Brantingham Thorpe the Kellaways Rock makes the low sandy mound known as "Sand Hill," but there is so much superficial sand about here that it is difficult to separate one from the other, or to trace its outcrop with much certainty.

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* Called *Wold Dale* on the one-inch map.

It probably skirts round the flanks of Mill Hill, west of Elloughton, and thence across the flat to the Humber; but it is entirely hidden in this part of its course by the great thickness of superficial beds. It may, however, have been met with in the well mentioned on p. 32.

The projection of the land at Oyster Ness is very likely caused by the outcrop of this bed; but the rock itself, if present, is quite concealed by the mud-banks of the Humber.

Oxford and Kimeridge Clays.—These clays being only seen at a few places, and there being no good lithological or palæontological division between them, are better described together. The lithological character of the clays seems to be nearly the same throughout; but, as only beds near the base and near the top are seen, one cannot be positive on the matter, nor draw an exact line between the two formations.

These clays in a general way occupy the immediate slope below the Chalk, from Newbald southwards to Welton. There are no sections in the northern part of their course, and the outcrop is only indicated by a narrow band of clayey ground. In the neighbourhood of the Drewton Valley, however, the banks become steeper, and the clay is occasionally exposed in small landslips; it is also seen in the beck above the Manor House, but the best section was exposed in the new railway immediately above the great Kellaways Rock section. A few feet of clayey shales were here seen, resting directly on the sandstones of the Kellaways Rock, and containing *Belemnites hastatus* and *Gryphæa dilatata;* but how far these beds may extend to the east there is no means of judging, as the cutting soon ends in that direction. Very dark clays, having a very Kimeridge aspect, although no fossils were found, are seen in the next cutting, and it is possible that a division might be drawn in the hollow between. From Drewton, besides *Belemnites hastatus* and *Gryphæa dilatata, Ammonites Comptoni, Ammonites Elizabethæ, Ostrea gregaria,* and *Pecten* were obtained.

In the trial shaft at Woo Dale, 23 feet of shale were passed through above the Kellaways Rock, and there are about 80 feet more of clay in the bank above, before these beds are overlapped by the Chalk, so that there must be over 100 feet of these clays at this place, but how much should be given to each formation there is not sufficient evidence to say. Although the clay is frequently exposed in small slips about here, no fossils were apparent beyond the ever abundant *Gryphæa dilatata.*

At Welton there are some old clay-pits on the west side of the village, in which these beds have been worked, but these are now grass-grown and obscured, and the only fossil we could obtain was the fragment of a *Belemnite.*

Professor Phillips mentions *Ostrea deltoidea* from Elloughton and Welton, so that it would appear that beds of undoubted Kimeridge age occur at least here, if not further north.*

East of Welton the base of the Chalk comes down to the level of the flat, and the outcrop of the clays is completely hidden by the thick deposit of Boulder Clay and Gravel.

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* Geology of the Yorkshire Coast, 3rd Ed., p. 244. *See also* Rev. W. Vernon, *Ann. of Phil.* ser. 2, vol. xi., p. 437.

CHAPTER V.

CRETACEOUS ROCKS.

Red Chalk.—In this district the Red Chalk maintains much the same aspect as it has to the north, in 93 N.E., although it is perhaps slightly thicker and also less conglomeratic than it was in the extreme north-west of its outcrop, the included pebbles being of less size than about Acklam. The thickness of the bed is probably about 6 feet, but there is no section in which the whole of this is seen.

The outcrop of the Red Chalk, forming as it nearly always does the junction between the dry ground of the Chalk and the wet land of the clays below, is easy to follow, except where hidden by landslips or great masses of chalk detritus.

In the fields about Kildwick Percy Hall fragments of Red Chalk are seen, but the outcrop is much hidden by the thick deposit of chalk débris or gravel which covers the hill at the back of the house. This deposit is so peculiar, and the surface of the ground so much resembles a Chalk country, that at first we thought the outcrop of this bed extended a mile further to the west to the edge of the hill at Wood House, but the Chalk fragments that are seen are rounded, and there is nothing to warrant this area being put in as Chalk. In the Park to the east the Red Chalk is hidden by landslips, but is seen at the spring near the road to Warter, and also in the bottom of an old quarry above Denison's Wood. In the valley leading up to Warter the outcrop is exposed at several places, more particularly at the brickyard on the north side of the Park, where, although the beds are much slipped, the following sequence may be made out:—

Section at Warter Brickyard.

Grey Chalk above	
Red Chalk	2 6 to 3 0
Yellow marl	1 0
Brown and blue Lias clay	

On the opposide side of the little valley in which the brickyard is situated, in Highcliff Plantation, the Red Chalk presents quite a brecciated appearance; and, being very hard, lies about the surface of the ground in large blocks. In Warter village the outcrop is exposed in several places, and, being very irregular, looks almost as if it were faulted, although the appearance is probably only due to the very uneven surface upon which the Chalk was originally deposited.

From Nunburnholme southwards the Red Chalk is easily traced. It has been met with in foundations in the village of Londesbrough, and runs up the two valleys to the east for a considerable distance. The further of these presents one of the best illustrations of the great unevenness of the surface upon which the Chalk was deposited; for on the west side of this valley, at Park Farm, the base of the Chalk is above the 200 ft. contour; whereas on the east side it is below the bottom of the valley, which is here about 175 feet above sea level. Thus on the two sides of the valley, which is only 90 yards wide, there is a difference of at least 30 feet in the level of the Red Chalk. Prof. Blake in his map of the Lias has a fault at this place, but if such were the case, one would expect it to be more apparent at either end of the valley.*

Between Londesbrough and Goodmanham, owing to the surface of the ground becoming flatter, the outcrop of this bed covers rather a larger space, and the fields are strewn with its fragments for some little breadth. At the latter village the Red Chalk is seen at numerous places in the valleys on either side, and there is a good section in the road just south of the railway, where the Grey and Red Chalk, the latter of which is very conglomeratic, are seen resting on the ironstone and clays of the Lias.

About half-way between Market Weighton and Sancton, at the point where the Red Chalk crosses the road, there may be a small fault, the Oolite being seen in the field to the south at a considerably higher level than the outcrop of the Cretaceous Beds in the road. As the Red Chalk, however, sinks again almost immediately to its original level, we considered that the beds were not faulted, but that this was merely a small hill of Oolite against which the Cretaceous Rocks were deposited.

At Sancton the Red Chalk is exposed in the lane above the village and elsewhere. In the farmyard at Newbald Sike 5 feet of Red Chalk are seen resting on clay, and at North Newbald the outcrop is marked by the copious springs which rise in the valleys above the village.

In the neighbourhood of Drewton the outcrop of the rock is very clear; 3 to 4 feet of Red Chalk are seen in the bank above Kettlethorpe, and the bed was exposed in the railway cutting at Drewton Manor House and near Weedley Springs, these fine springs being thrown out by the junction of the Chalk with the clays below. Messrs. Keeping and Middlemiss give the following section from one of these cuttings.†

	FT.	IN.
Nodular Red Chalk	1	6
Pale Nodular Chalk	1	3
Clayey Red Chalk	0	6
Grey Nodular Chalk	1	0
Red Chalk	0	3
Yellow-green Clay	0	9
Unctuous Red Clay	1	6
Total	6	9

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* For similar cases and for illustrative sections *see* The Geology of the Country around Driffield (Explanation of Quarter-Sheet 94 N.W.), p. 8. Also J. R. Mortimer: On the origin of the Chalk Dales of Yorkshire.—*Proc. Yorksh. Geol. Soc.*, vol. ix., p. 29.

† *Geol. Mag.*, dec. ii., vol. x., p. 218.

The next exposure of any consequence is at the corner of Woo Dale, just north of Brantingham, where a small landslip has exposed the Red Chalk resting on clay with *Gryphæa dilatata.* Copious springs are also thrown out on the east side of the village along the line of outcrop. At the Hall the outcrop is more obscure, but it will probably be just below the house, as the cellars of that building are said to have been excavated in Chalk.

At Welton Springs there is a good exposure of the Red Chalk, and, judging from the nature of the ground, the outcrop passes just above Welton House, but beyond this it is covered by Boulder Clay, and there is no evidence as to where it strikes the Humber.

Lower Chalk.—The Grey Chalk, or Chalk-without-Flints.— Above the Red Chalk, and at the base of the great mass of white chalk which forms the Wolds, there are about 50 feet of grey marly chalk without flints. These beds generally occupy a narrow band along the edge of the Wolds, and form the steeper part of that escarpment. The upper limit of this division is generally marked by a dark carbonaceous shaly band, containing plants and fish remains, which is usually seen wherever a section happens to have been opened on this horizon, and has been observed at a few places in this district. The lower part of these beds is generally seen wherever there is a good exposure in the Red Chalk, particularly about Warter, where there are numerous sections, the greater part of the village standing on this bed. In a quarry between the two valleys at Londesbrough the junction of this bed with the flinty chalk is exposed; the line being marked by a peculiar band, which weathers in vertical lines, giving the bed a columnar aspect.*

In the second valley, opposite Park Farm, there is an exposure showing beds of pink and grey chalk; and it is probable that these pink bands occur throughout the outcrop of the Grey Chalk, but, from the want of good sections, have not been very generally observed, although there are indications of them in the valleys north and south of Goodmanham, at Newbald Sike, and near South Newbald. In the road going up the Wold from the latter village the Grey Chalk is well exposed; and the dark shaly band at the top, which is a foot or more in thickness, is seen just at the angle of the road. This band was also exposed for some considerable distance in the railway cutting near Weedley Springs.

The Grey Chalk is seen in the Beverley Road in Brantingham Dale, and at several places about Elloughton and Welton; but the most interesting section is at Graystones Chalk Pit in Melton Bottom, where the dark shaly band, about a foot thick, is exposed between the flinty and non-flinty chalk, and affords a key to this horizon just before it passes beneath the Boulder Clay in the low ground between here and the Humber.*

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* This peculiar band of chalk was first observed by Mr. A. J. Jukes-Browne in Lincolnshire. *See* Memoirs of the Geological Survey. Explanation of Quarter-Sheet, 94 N. W., p. 10.

The Middle Chalk.—This division, which comprises the greater part of the area covered by the Chalk, has a thickness of probably between 300 and 400 feet. It is, however, on account of the paucity of its organic remains, less interesting than the other subdivisions of the formation. The distribution of flint in the Chalk is sufficiently constant to this particular horizon to constitute a rough guide in tracing these subdivisions across the country. In a general way it may be said that this division contains in the upper part thick tabular flints which, lower down, split up into nodules, and, quite at the base, die out. Prof. Blake has divided this part of the Chalk into three palæontological zones, thus:—†

Lithology.	Palæontology.	Thickness in Feet.
Chalk with imperfect flints -	Zone of Micrasters	120
Chalk with many tabular flints -	Barren zone -	50
Slaty Chalk with thin flints	Zone of Inoceramus mytiloides.	200
Creamy Chalk with nodular flints		

The Upper Chalk.—This division, which constitutes the upper or flintless portion of the Chalk, is not well exposed in this district. It only crops out on the lower slopes of the Wolds near Kilnwick and Beverley, and is generally covered more or less by Boulder Clay.

The line separating these beds from the flinty chalk below is only very general. In order to accurately trace this junction it would be necessary to obtain more palæontological evidence.

In calculating the thickness of the Chalk it is interesting to note at what depth the base of the formation has been reached at different places.‡ Thus, at—

	Feet.
Swanland the base was reached at - - -	247
Humber Dale Farm - - -	169
Springhead - -	400
Dairy Cotes - - - - - - -	325 ?
Hull - - - - - -	536

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[*] Mr. Blake alludes to this band in his paper "On the Chalk of Yorkshire." —*Proc. Geol. Assoc.*, vol. v., p. 250.

[†] *Loc. cit.*, p. 262

[‡] The details of some of these sections and many others are given in the Memoirs of the Geological Survey.—The Geology of Holderness.

CHAPTER VI.

SUPERFICIAL DEPOSITS.

Boulder Clay, Sand and Gravel.—Most of the superficial deposits with which we have now to deal may be divided into two areas; namely, those to the west, covering the great plain of the Vale of York, and those to the east, forming the extensive flat of Holderness. These two districts are divided by the range of the Chalk Wolds, which are nearly free from superficial beds, although they sweep up the slope on either side, and even occasionally occur on the higher ground; while a narrow strip also passes round by the Humber, connecting these two areas by that valley.

In the first of these districts the Boulder Clay covers a large extent of country, probably nearly the whole of the plain south east of York; but, being generally covered by beds of later age, it is only seldom seen at the surface, and occupies comparatively but a small space on the map. Its principal exposures are along the two great ridges crossing the plain at York and Escrick. These ridges rise to a height of from 30 to 60 feet above the flat, and have a very remarkable appearance, which it would be interesting to study in relation to the physical structure of this extensive valley.

The Boulder Clay has been met with in several wells and borings in the low ground, details of which are given further on. In the railway cutting at Escrick, 20 feet of Boulder Clay are exposed, but it must be thicker than this in some cases, although from the borings it is difficult to make out what is really Boulder Clay. The sands and gravels of glacial age cover a somewhat larger area than the clay, and occur along the ridges just mentioned; sometimes intercalated in the Boulder Clay, as at York, and sometimes resting on that formation, as at Newton. Besides these there are considerable deposits of gravel about the isolated hill of Holme-on-Spalding-Moor, and along the flanks of the hills between Pocklington and Market Weighton, at North Cave, at Everthorpe, and from Brantingham southwards to the Humber.

The gravels which cap the hill at Holme-on-Spalding-Moor are at an elevation of 150 feet above the sea, and are mostly composed of western rocks similar to those about York and along the Escrick ridge; while those on the flank of the hill, which are 50 or 60 feet lower, are mainly formed of fragments of local rocks.

At North Cave the gravels which are stratified and rounded are composed almost entirely of Lias fragments; and the great quantity of specimens of *Gryphæa incurva* contained in them is very remarkable; in some of the pits between North and South Cave this shell is so abundant as to warrant their being called a "Gryphite gravel."*

Along the ridge between Ellerker and Brough similar coarse gravels occur, but here most of the included fragments are from the Oolite; and it is curious to observe in both these cases that the rocks from which these gravels are derived outcrop at the spot or lie immediately to the north.

A pit near Brough well shows the irregular character of this gravel. It consists mainly of Chalk and Oolite; but there are some foreign pebbles, as well as fragments of ironstone, coal, and decayed wood. The sand lies in wavy beds, presenting a very marked appearance in the lower part of the section. The upper part has at one time been used as a burial place, as numerous bones, as well as entire human skeletons and urns with burnt bones, have been dug out.

The slight hollow in the Oolites east of Ellerker is filled with a deposit of sand and chalk gravel, which is 4 feet thick in the shaft at Woo Dale; but increases to 7 feet in the boring near Elloughton, where it rests on 13 feet of clay with flints; and to 26 feet in a well south of that village, where it rests on clay. The section here is—

Well, a quarter of a mile south of Elloughton.

	Ft.	In.
Sand	26	0
Clay	14	0
Stone	6	0
Clay	4	0
Total	50	0

Whether the upper of these clays is Boulder Clay is not certain, although it probably is, and in that case the 6 feet of stone would be the Kellaways Rock. About Brough these sands and gravels are probably thicker, but the sections there are not reliable. At Melton the sand and gravel dies out, but at Red Cliff, on the Humber bank, there is an isolated patch resting on stiff purple Boulder Clay.

Besides the above there is a curious deposit covering the hill at Kildwick Percy, which, from the pits in it being called "Old Chalk Pits," we were led to think would be part of the Chalk formation. Although the surface is covered with flints and chalk fragments, unfortunately there are no sections in which one could see the bed; but the fragments ploughed up in the fields were rounded, and, as the Red Chalk certainly crops out at a higher level to the east, we came to the conclusion that this bed, although excessively like solid chalk, must be either a landslip or a large mass pushed off from the Chalk above, or possibly a thick deposit of chalk-gravel. On the edge of the hill at Everthorpe there is also a patch of chalk-gravel, which has been cut through by the railway, and exposes a good section showing that this gravel has been deposited against an old bank of the Middle Lias, and extended that feature about 200 yards further to the west, causing a deceptive appearance of the outcrop.

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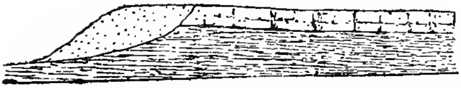
* *See* Tate and Blake: The Yorkshire Lias, p. 69.

Fig. 1.

Diagram showing extension of the Middle Lias feature by Chalk Gravel at Everthorpe.



On the eastern side of the Chalk Wolds the Glacial Beds run up to about the 200 ft. contour line at Lund, the 250 at Walkington, and nearly to the 300 at Swanland, although sporadic drift-pebbles are found much higher. From these elevations the drifts spread over the slope to the east, forming a thin covering to the Chalk, till they reach the edge of the great Holderness plain, and become partly covered with beds of later age, when they increase enormously in thickness, and the Chalk is entirely lost sight of, except where reached in deep borings.

At Middleton-on-the-Wolds there occurs a large patch of flinty gravel, probably of Glacial age, at the height of 186 feet above the sea. There are also near Lair Hill several patches of gravel, composed of chalk and drift pebbles, at the height of 200 feet above the sea.

In Holderness there occur, along with the Boulder Clay, large masses of sand and gravel. These are often, as near Brandsburton, arranged in long narrow curvilinear mounds, like Eskers. Marine shells have been found in many of these mounds, principally *Tellina balthica, Cardium edule, Purpura, Mya, Cyprina islandica, Astarte borealis, Balanus.*

At Swanland several large boulders of Whinstone and other rocks have been found, several of which are a yard or more in diameter.

The Boulder Clay on the Wolds is generally very thin, and is then of a reddish colour throughout. The colour may be due to its consisting mainly of insoluble chalk residue; but is perhaps more probably due to weathering, as we noticed that near Cherry Burton, where it is much thicker than usual, the lower part was blue.

As the Boulder Clay and Gravel on the east side of the Wolds and at Hessle are treated at length in the general Memoir on the Holderness district, where a more detailed account of this area is given, it will not be necessary to say more on the subject here.*

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* Memoirs of the Geological Survey.—The Geology of Holderness, by C. Reid.

Chalk Gravel, capping hills.—These gravels are a continuation of those mentioned in the Explanation to Quarter-Sheet 93 N.E. as capping the low hills north of Pocklington, and as containing recent land shells; for this reason they have been mapped separately, but it is doubtful whether all the gravel classed under this head is of post-glacial age.

These gravels, which are mainly composed of chalk fragments, are seen in the railway cutting north of Pocklington, where they have been worked for ballast, and from which pit we obtained *Succinea putris* in marly seams in the gravel. South of Burnby there is a similar gravel, occupying about the same position, but we have not obtained any direct evidence as to its age.

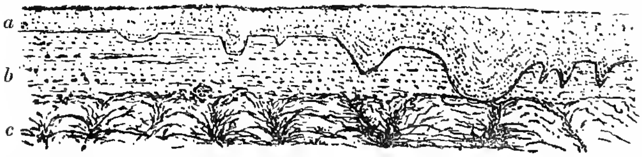
On the eastern edge of the Wolds there are several patches of chalky gravel, occupying a similar position to that between Burnby and Market Weighton. These gravels in some places line the edge of the flat country after the manner of a beach, as at Beswick, near Scorborough; and in others run up the Wold valleys for some distance. They appear to be old river gravels merging into sea beaches; and are probably of late glacial age, at least in some cases. One of these gravel patches, occupying a dale between Burn Park and Skidby, seems to be under Boulder Clay.

Gravel of Dry Chalk Valleys.—In bottoms of all the valleys in the Chalk, especially when they are of any size and are not cut down to the clays below, there is a deposit of gravel composed of chalk fragments and flints, which has evidently been formed by the disintegration of the beds *in situ*, and has not been brought from a distance. The formation of this gravel seems to be going on to a great extent at the present time, and in many cases is probably due to the wash from the steep banks on either side. A section in these beds was exposed at the side of the railway, about a mile above Goodmanham Spring, which showed horizontally stratified gravel, composed chiefly of chalk flints, below brown sandy beds with a few flints; the stratification of these latter being bent round in hollows of the lower bed, showing that the support had given way since their deposition.

Fig. 2.

Section in Chalk Valley Gravel.

Railway cutting near Goodmanham Lodge, Market Weighton and Beverley Railway.



a. Brown sandy soil with a few chalk flints; the stratification being bent round in the depressions.

b. Gravel or wash of chalk flints, chalk and sand; horizontally stratified.

c. Talus.

The relation of these gravels to those along the east flank of the Chalk is very obscure, but it is very probable that they are of the same age. Where these valleys come down to the flats of Holderness no division can be made between them.

In many places on the Wolds is found a curious deposit, locally known as "gruts" or grits, consisting of finely comminuted chalk débris of a dirty character.

The gruts are generally found along the sides of the Wold dales; but in some places they lie on plateaus. They have been dug out for gravel, and more frequently for mortar.

Occasionally these angular chalk gravels are cemented together, forming a breccia of chalk flints which is very hard, and stands out from the sides of the dale in a bold crag. St. Austin's Stone above Drewton is a remarkable instance of this.*

Warp and Lacustrine Clay, Sand and Gravel.—These deposits cover nearly the whole of the surface between York and the Humber, forming the great plain west of the Wolds, which is only broken by the low hills about York, the ridge running through Escrick, and the isolated hill of Holme-on-Spalding-Moor. This plain, which from a distance appears perfectly flat, is in reality slightly undulating from the denudation of the rivers and smaller local streams, and from the fact of the sands occupying rather higher ground than the clay.

The annexed sketch (p. 36) shows the rolling nature of the warp beds.

These beds have a thickness varying from 25 to 90 feet, although in some cases, especially near the edge of the rising ground, they thin away to less than this, and in a few places are so thin that the Boulder Clay almost appears through, and might be mapped in preference to these deposits.

The sands which cover a large portion of the district west of the Wolds have a thickness varying from a few inches to 10 or 15 feet. They consist of clean yellow and white soft sand, which is often ferruginous, and causes the water issuing at their base to be highly charged with iron. These sands are frequently interstratified with thin seams of peat and black earth, containing freshwater shells and plant remains, which give to the surface the character of a black sandy mould.

Numerous sections in these beds have been obtained from bore-holes and clay-pits, of which Dr. Parsons has obtained the details of a great number; these, together with others, we reproduce in the Appendix, as they afford a valuable insight into the structure of this great plain.†

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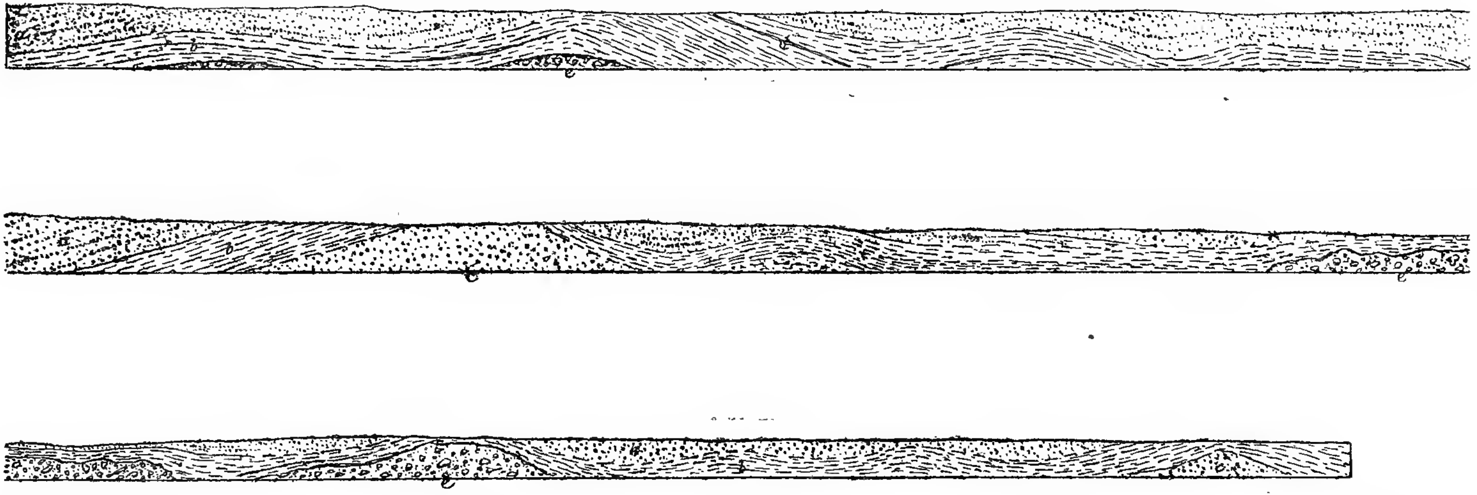
* Mr. Cole gives an illustration of this stone in the frontispiece to "Notes on the Geology of the Hull, Barnsley, and West Riding Junction Railway and Dock." 8 vo. Hull, 1886.

† *See* Appendix 1. Compare also those given on pp. 3–10.

Fig 3.

Section near Stillingfleet, showing rolling warp upon Boulder Drift. (Copied from a drawing by J. C. Ward.)



This section was exposed in a ditch, four or five feet deep, alongside the new line between York and Selby; beginning close to Escrick House (? Grange), and going northwards.

Unfortunately, the description of this drawing has been lost; but it is probable that (*a*) represents the sand, (*b*) the warp clay, and (*e*) the boulder clay; while (*c*) may be sand or gravel, and (*d*) a sandy seam in the warp clay.

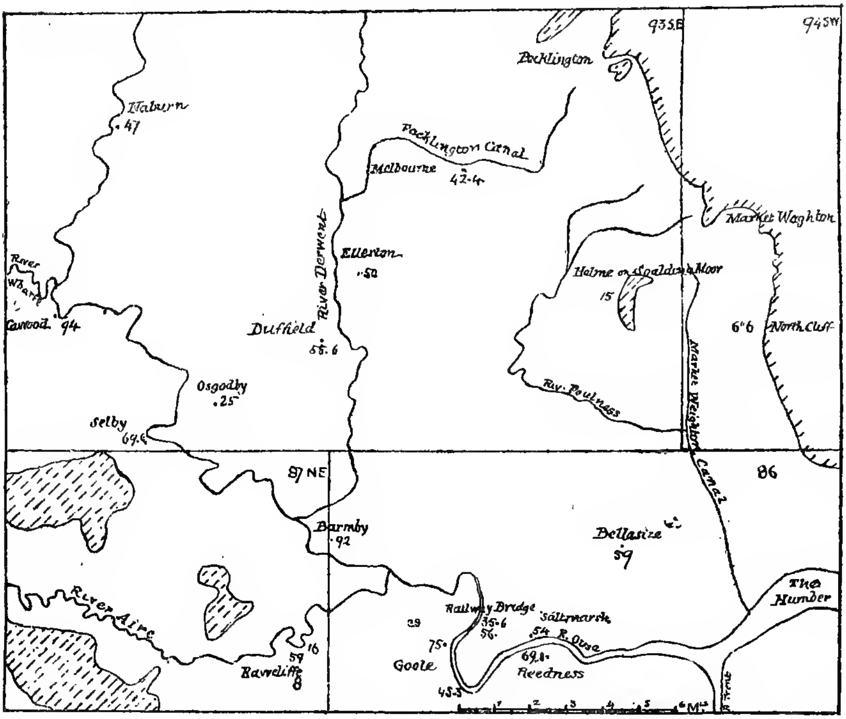
From these sections it will be seen that there is usually a thick deposit of laminated clay below the superficial sands, and in the vicinity of the Humber a bed of peat.

This peat thickens to the south of Goole, and is probably the same as that exposed in the banks of the Humber at Melton, South Ferriby, and Whitton.

It is also interesting to observe that the thickness of the superficial beds varies considerably in short distances, and that consequently the old surface of the Trias was much more uneven than the present surface of the country. The accompanying sketch-map renders this more apparent.

Fig. 4.

Map showing the Area and Thickness of the Superficial Deposits.



The figures represent the thickness of the superficial beds at the several places. The shaded areas are where the solid rock comes to the surface. (*See* pp. 3–10, and Appendix I.).

The most interesting circumstance, however, connected with these deposits in this district was the finding, several years ago, of a large collection of bones of extinct animals at Bealsbeck, about 2½ miles south of Market Weighton, and nearly a mile west of the Lias escarpment of North Cliff. A full account of this ossiferous marl is given by Professor Phillips.* It appears that the remains found consisted of Elephant, Rhinoceros, Bison,

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* Geology of the Yorkshire Coast, 3rd edit., p. 12.

Stag, Horse, Wolf, &c., together with land and freshwater shells. The majority of the bones were found at a depth of from 10 to 20 feet, and must have occurred in a hollow in the Keuper Marl, as the marl is exposed in several pits about here with only a slight covering of sand varying from 3 to 8 feet in thickness.

Bones of animals are also found from time to time at other places in this neighbourhood, the tibia of the Mammoth having been found in digging for marl at Harswell, and remains of *Bos longifrons* in excavating at Pocklington.

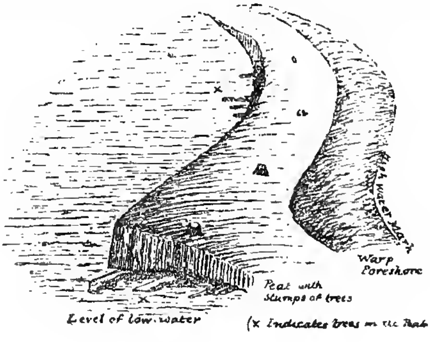
In the low ground in the neighbourhood of Pocklington there is a large spread of chalk gravel, the age of which is somewhat doubtful. From its general character it has been mapped with the alluvial deposits, but it may be of older date, if not of glacial age; in some cases it seems to join on with the gravel capping the hills, to which it is very similar.

Alluvium, Modern Warp and Peat.—Along the sides of the principal rivers, such as the Ouse, Derwent, and others, there is a strip of modern alluvium, forming a narrow tract below the level of the surrounding country. This, as it approaches the Humber, becomes merged with the modern warp or tidal alluvium of that estuary, which latter is continuous with the ancient warp mentioned above, so that no lines can be drawn between them. At Brough there are 18 feet of this clay.

Intimately associated with these deposits is a bed of peat, which varies in thickness from a few inches to as much as 20 feet. It is well exposed in the Humber at Melton below high-water mark, and has been met with in several of the sections given above. This peat contains the stumps and trunks of great numbers of trees, the former being firmly rooted in the sands, and exhibiting the marks of tools with quantities of waste chips, thus showing that these beds have been covered up since the advent of man.

Fig. 5.

Sketch of the Humber-Shore at Melton, showing Peat with Stumps of Trees.


High water mark
Warp Foreshore
Peat with Stumps of trees
Level of low-water
(× Indicates trees on the Peat

Blown Sand.—In the neighbourhood of Sancton, and also covering the Lias terrace between Houghton and North Cave, is a vast deposit of sand, which about Houghton Moor has entirely altered the aspect of the country, and instead of the ground being, as one would expect, a stiff clay from the Lias, it is quite a sandy desert. This sand, which has evidently been blown from the plain to the west, covers the Oolites and Chalk about Sancton, rising to an altitude of 400 feet above sea-level.

The sandy mounds below Cliff and elsewhere in the plain have very much the aspect of sand dunes, and it is in all probability from here that these sands originally came.

CHAPTER VII.

PHYSICAL STRUCTURE.

Lie of the Rocks, Faults, &c.—The physical structure of this district is extremely simple, and divides the country, as we mentioned above, into three areas,—the great plain between York and the Humber, the flat land of Holderness, and the range of the Chalk Wolds dividing these two from one another. The two former of these areas are everywhere, except about the isolated hill of Holme-on-Spalding-Moor, covered by superficial deposits, and the solid rocks do not come to the surface, except where they approach the flanks of the Wolds on either side. They form a great plain, not usually rising above the 50-ft. contour, except where hills of Boulder Clay and Gravel break this dull monotony, and form mounds and undulating ground attaining an elevation of from 50 to 100 feet above sea level.

The central area, which comprises the southern portion of the Yorkshire Wolds, rises along its western scarp to heights varying from 500 to 600 feet above sea-level; but the majority of the Wolds do not attain an elevation so great as this, and the ground falls gradually to the east till it passes under the Boulder Clay and superficial deposits of the flats of Holderness.

The great pre-cretaceous anticlinal which separates the Oolites and the greater part of the Lias of South Yorkshire from that of the northern part of the county, passes a little to the north of this area, so that all the beds of this age with which we have to deal are on the southern slope of this ridge; and the denudation being greatest at the axis of disturbance, we have higher beds the further we get from that line.

With the exception of this main upheaval there are no faults or disturbances of any magnitude. A small fault occurs to the west of Londesbrough, which throws down the Lias on the western side, forming the great spread of that rock about Cleaving Grange; and, from the greater thickness of beds exposed beneath the Chalk, causing the little patch of Middle and Upper Lias to appear. This fault appears to have somewhat affected the Cretaceous rocks, as the Chalk itself is considerably disturbed at this point, although the beds are not much shifted. This appears to be the only instance in which the beds are absolutely broken. Messrs. Tate and Blake,* in their map of the Lias of this district, have considered that the beds are faulted at no less than six places, and it is a curious fact that these are all placed where there is a valley coming out from the Chalk; but the dip of the beds is sufficient to account for the apparent irregularity in crossing these valleys, and we could find no positive evidence of faulting.

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* The Yorkshire Lias, p. 208, and map.

The base of the Chalk, as we mentioned in describing the outcrop of the Red Chalk, is excessively irregular; and in several of the valleys, especially about Warter, Londesbrough, and Goodmanham, has, at first sight, very much the appearance of faulting. But although the difference of level is considerable on the opposite side of these valleys, it is not more than one would expect from the very uneven surface upon which the Chalk was deposited.

There is apparently a slight anticlinal at North Cliff, just bringing up the Rhætic Beds on a level with the plain, but the effect may in great measure be due to the slightly more western extension of the outcrop at this point.

APPENDIX I.

WELL SECTIONS.

Kelfield Brick and Tile Yard.

	Ft.	In.
Yellow sand	5	0
Leafy clay	30	0
Total	35	0

*Brickyard between Riccall and Escrick.**

	Ft.	In.
Top soil	1	0
Brown peaty sand	1	0
Yellow sand; surface eroded; hollows lined with parting of clay	2	0
Coarse brown sand	1	0
Gravel	0	6
Laminated clay	10	0
Total	15	6

Same as above. Account given by Foreman of Works.

	Ft.	In.
1. Sand, rather gravelly	5	0
2. Warpy clay (used for bricks and pantiles)	6	0
3. Strong blue clay (used for drain pipes)	8	0
4. Fine leafy (warpy) clay	6	0
5. Rotten peat	—	
Total	25	0

*Well at North-Eastern Railway Lodge, between Barlby and Riccall.**

	Ft.	In.
Top soil	1	6
Sand	3	0
Clay	12	0
White quicksand	1	0
Clay	—	
Total	17	6

Well at Hall Farm, Duffield.

	Ft.	In.
Soil	1	6
Clay	6	6
Yellow sand	6	0
Strong clay	14	0
Silty clay and warp	16	0
Coarse sand and gravel, with water	0	3
Strong blue clay	6	6
Strong red clay	4	9
Total	55	6

The Red Clay is said to be very earthy, and is probably lying on the Red Sandstone.

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* From Dr. Parsons' account, *Proc. Yorkshire Geol. Soc.*, vol. vi., p. 238.

No. 1.—*Barmby on the Marsh: Trial holes for Hull and Barnsley Railway.*

	Ft.	In.
Yellow clay	2	0
Peat and wood, much decayed	11	0
Total	13	0

No. 2.—

	Ft.	In.
Clay	2	0
Peat	8	0
Clay	—	
Total	10	0

Well at Black Swan, Eastrington.

	Ft.	In.
Clay*	60	0
Gravel, with water (reached)	—	
Total	60	0

Brick and Tile Yard, Eastrington.

	Ft.	In.
Blue clay	4	0
Sand	0	7
Black clay	9	0
Silty clay.—Laminated clay with partings of dry sand. Can go 40 feet in this clay, which is nearly free from stones; only one or two cobbles being found in a year.		

Staddlethorpe Station.

	Ft.	In.
Gravel	60	0
Marl	140	0
Total	200	0

Brickyard at Staddlethorpe.

	Ft.	In.
Sand	3	0
Yellow clay	1	6
Strong clay (with limestone)	2	0
White clay	6	0
Black clay	40	0
Total	52	6

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* The lower part of the clay is probably Boulder Clay.

Brickyard at Thimble Hall.

	Ft.	In.
Thin sand	1	6
White clay	4	6
Black clay	30	0
Total	36	0

Howden Brickyard.

	Ft.	In.
Soil	1	6
Strong clay	7	6
Yellow sand	1	2
Silty warp	1	6
Stronger clay with selenite	14	0
Total	25	8

*Marl Pit at Cliff Warren, near Market Weighton.**

	Ft.	In.
Surface soil	0	6
Yellow sand with peaty layers indented by a subjacent bed of gravel consisting of chalk flints	3	0
Laminated clay	2	0
Sand and gravel, containing chalk flints, fragments of Keuper Marl and Lias with *Gryphæa incurva*	1	6
Keuper Marl	—	
Total	7	0

Temple Holes, near Holme.

	Ft.	In.
Sand with a peaty top and gravelly base, flints, &c.	10	0
Thin clay on Keuper Marl	—	

Brickyard at River Bridge, Market Weighton Canal.†

	Ft.	In.
Warp	1	0
Peat	0	6
Sand, white under peat, then strongly ferruginous, then yellow, gravelly at bottom	8	0
Grey clay, strongly laminated	15	0
Total	24	6

Well at New Village.‡

	Ft.	In.
Soil	1	6
Blue clay	4	0
White clay	4	0
Black clay	30	0
Total	39	6

These are all warp clays. The white clays makes beautiful white bricks.

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* From Dr. Parsons' account, *Proc. Yorkshire Geol. Soc.*, vol. vii., p. 161.
† From Dr. Parsons' account, *Proc. Yorkshire Geol Soc.*, vol. vi., p. 238.
‡ From Mr. Clarke, Knedlington, Howden.

Railway Cottages, Bromfleet Carrs.

	Ft.	In.
Clay	3	0
Peat with decayed reeds	20	0
Total	23	0

The water is bad.

Brick and tile yard, Bromfleet Landing.

	Ft.	In.
Sandy soil	2	0
Laminated clay	15	0
Strong clay (not excavated)	—	
Total	17	0

Cemetery, Welton.

Soil and sand, with a flint or two	4	0
Gravel, mostly chalk, some large flints	2	0
Very fine gravel with pebbles	2	0
Coarser gravel composed of chalk, granite, quartz, and grit	2	0
Bottom of excavation	10	2

The above said to overlie strong red clay.

Brickyard, Melton Creek.

	Ft.	In.
Laminated clay	8	0
Thin peaty clay	1	0
Gravel (bottom not seen)	1	0
Total	10	0

A human skeleton, horns of deer, and stumps of trees, with waste chips showing axe marks, were found in the peaty clay at 5 feet.

Well at the New House, Ferriby Landing.

	Ft.	In.
Silty clay, warp (sunk)	24	0
Strong clay (bored)	10	0
Total	34	0

Total clay said to be 70 feet.

Well at North Ferriby.

	Ft.	In.
Blue stony clay	200	0?
Chalk with water		
Total	200	0

Well at Hessle.

	Ft.	In.
Clay	18	0
Chalk	—	
Total	18	0

On line of Hull Waterworks Tunnel, half a mile east of Springhead Pumping Station.

	Ft.	In.
Soft marly clay, warp	50	0
Chalk (bored)	350	0
Clay (reached)	—	
Total	400	0

Dairy Cotes, Hull.

	Ft.	In.
Warp	20	0
Peat	2	0
Clay with small checkers	19	6
Sand with shells	12	6
Chalk	—	
Total	54	0

Dairy Cotes, Humber Foreshore.

	Ft.	In.
Alluvial deposits, clay, silt, and sand	45	0
Drift	45	0
Chalk	235	0
Total	325	0

Well at Routh.[*]

	Ft.	In.
Fine sand[†]	40	0 ?
Blue clay	10	0
Chalk	—	
Total	50	0

Well at Beverley Park.[*]

	Ft.	In.
Red clay	15	0
White gravel	15	0
Chalk	—	
Total	30	0

Cottingham Churchyard.

Chalk at 30 feet.

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[*] Supplied by Mr. Villiers.

[†] Thickness of sand doubtful; may be alternations of sand and clay.

Since the above went to press, Mr. Cole has published some geological notes for the engineers of the Hull and Barnsley Railway Company from which the following sections are taken :—*

Boring at Barmby on the Marsh.

		Ft.	In.
Superficial beds, 52 ft.	Yellow clay	7	0
	Blue clay	8	0
	Peat and tree trunks	9	0
	Clay and peat	2	0
	Loamy sand	2	0
	Clean sand	2	0
	Very hard brown clay	12	0
	Stiff brown clay	10	0
	(At this point water came to within 6 ft. of the surface.)		
	Red sand	17	0
	Bluish red marl	1	6
	Dirty white sand	1	0
	Marl and sand mixed	3	6
	Very coarse red grit	2	0
	Clean red sand	7	0
	Red marl	5	0
	White sand	0	9
	Total	89	9

Trial-holes, Hull and Barnsley Railway, in crossing Walling Fen.
Section A.—West.

	Ft.	In.
Clay	6	3
Peat	3	0
Sand	2	0
Total	11	3

Blue clay.

Section B.—Centre.

	Ft.	In.
Peat	8	6
Clay	16	0
Total	24	6

Hard sand.

Section C.—East.

	Ft.	In.
Yellow warp	5	6
Green warp	6	0
Peat	19	6
Total	31	0

Hard red clay.

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* Rev. C. M. Cole.—"Notes on the Geology of the Hull, Barnsley, and West Riding Junction Railway and Dock."—8vo. *Hull*, 1886, pp. 17, 19.

APPENDIX II.

LIST OF SOME OF THE WORKS REFERRING TO THIS DISTRICT.

1788.

MARSHALL, W.—The Rural Economy of Yorkshire, 8vo. *London.*

1794.

LEATHAM, T.—General view of the Agriculture of the East Riding of Yorkshire (Map and Account of Soils). 4to. *Lond.*

1799.

ALDERSON, DR. J.—Geological Observations on the Vicinity of Hull and Beverley. *Journ. of Nat. Phil. Chem. and Arts* (4to), vol. iii., p. 285.

1818.

MARSHALL, W.—The Review and Abstracts of the County. Reports of the Board of Agriculture from the several Agricultural Departments of England. 8vo. *York.*

1821.

SMITH, W.—Geological Map of Yorkshire. 4 Sheets.

1826.

VERNON, REV. W.—An Account of the Strata North of the Humber, near Cave (York. Phil. Soc.). *Ann. of Phil.*, ser. 2, vol. xi., p. 435.

1829.

PHILLIPS, PROF. J.—Illustrations of the Geology of Yorkshire, or a description of the Strata and Organic Remains of the Yorkshire Coast, 4to. *York.* Ed. 2 in 1835. Ed. 3 in 1875.

VERNON, REV. W. V.—On a Discovery of Fossil Bones in a Marl-pit near North Cliff. *Phil. Mag.*, ser. 2, vol. vi., p. 225.

1830.

VERNON, REV. W. V.—Further Examination of the Deposit of Fossil Bones at North Cliff in the County of York. *Ibid.*, vol. vii., p. 1.

1836.

MITCHELL, DR. J.—On the Chalk and Flint of Yorkshire, as compared with the Chalk and Flint of the Southern Counties of England. *Edin. New. Phil. Journ.*, vol. xx., p. 68. Abstract in *Proc. Geol. Soc.*, vol. ii., p. 113 (1835).

1841.

THORP, REV. W.—Report on the Agricultural Geology of Part of the Wold District of Yorkshire and of the Oolite in the Neighbourhood of North and South Cave, &c. *Proc. Geol. and Polytech Soc. W. Riding York*, vol. i., p. 207.

1843.

THORP, REV. W.—On the Indications which are Guides in judging of the Fertility or Barrenness of the Soil. *Ibid.*, vol. ii., p. 139.

1844.

Bray, W. B.—Description of the Ouse Bridge, on the Hull and Selby Railway (short note of the river bed). *Proc. Inst. Civ. Eng.*, vol. iv., p. 86.

1853.

Phillips, **Prof.** J.—A Map of the Principal Featnres of the Geology of Yorkshire. (Scale 5 miles to an inch.) *York.* Ed. 2 in 1862.

1858.

Norwood, **Rev.** J. W.—The Comparative Geology of Hotham, near South Cave, Yorkshire (Brit. Assoc.). *Geologist*, vol. i., pp. 420, 472.

1868.

Phillips, **Prof.** J.—Notice of the Hessle Drift, as it appeared in Sections about Forty Years since. *Quart. Journ. Geol. Soc.*, vol. xxiv., p. 250.

Wood, S. V., Jun., and **Rev.** J. L. **Rome**.—On the Glacial and Postglacial Structure of Lincolnshire and South-east Yorkshire. *Ibid.*, vol. xxiv., p. 146.

1870.

Wood, S. V., Jun.—On the Relation of the Boulder Clay, without Chalk, of the North of England to the Great Chalky Boulder Clay of the South. *Quart. Journ. Geol. Soc.*, vol. xxv., p. 90.

1872.

Blake, **Rev.** J. F.—On the Infralias in Yorkshire. *Ibid.*, vol. xxviii., p. 132.

Wood, S. V., Jun.—On the Climate of the Post-Glacial Period. *Geol. Mag.*, vol. ix., p. 153.

1874.

Blake, **Rev.** J. F.—On the Red Chalk in Yorkshire. *Geol. Mag.*, dec. ii, vol. i., p. 362.

1875.

Blake, **Rev.** J. F.—On the Kimeridge Clay of England. *Quart. Journ. Geol. Soc.*, vol. xxxi., p. 196.

Phillips, **Prof.** J.—Illustration of the Geology of Yorkshire. Part I.—The Yorkshire Coast. 3rd ed. 4to. *London.*

1876.

Barrois, C.—Recherches sur le Terrain Crétace Supérieur. 4to. *Lille.*

Tate, R., and J. F. **Blake**.—The Yorkshire Lias. 8vo. *London.*

1877.

Parsons, **Dr.** H. F.—The Alluvial Strata of the Lower Ouse Valley. *Proc. Geol. Soc. Yorkshire*, n.s., vol. vi., p. 214.

1878.

Atkinson, J. T.—On the History and Objects of the Society, especially with reference to the History of Selby and the Geology of Selby and the District. *Proc. Geol. Soc. Yorkshire*, n.s. vol. vii., p. 52.

Blake, **Rev.** J. F.—On the Chalk of Yorkshire. *Proc. Geol. Assoc.*, vol. v., p. 232.

———.—The Geological History of East Yorkshire. *Proc. Geol. Soc. Yorkshire*, n.s., vol. vi., p. 15.

Cole, **Rev.** E. M.—On the Red Chalk. *Ibid.*, p. 30.

1879.

Cole, Rev. E. M.—On the Origin and Formation of the Wold Dales. *Proc. Geol. Soc. Yorkshire*, n.s., vol. vi., p. 128.

Parsons, Dr. H. F.—The Trias of the Southern Part of the Vale of York. *Ibid.*, p. 154.

1880.

Wood, S. V., Jun.—The Newer Pliocene Period in England. *Quart. Journ. Geol. Soc.*, vol. xxxvi., p. 457.

1882.

Cole, Rev. E. M.—On the White Chalk of Yorkshire. *Proc. Geol. Soc. Yorkshire*, n.s., vol. viii., p. 21.

Wood, S. V., Jun.—The Newer Pliocene Period in Britain. *Quart. Journ. Geol. Soc.*, vol. xxxviii., p. 667.

1883.

Keeping, W.—The Geology of the New Railway Cuttings in the Cave District, South Yorkshire. *Ann. Rep. Yorks. Phil. Soc.* for 1882, p. 45.

——— and C. S. Middlemiss.—On some New Railway Sections and other Rock Exposures in the district of Cave, Yorkshire. *Geol. Mag.*, dec. ii., vol. x., p. 215.

Morris, John.—The Chalk, its distribution and subdivision. *Proc. Geol. Assoc.*, vol. viii., p. 208. (Refers to Yorkshire Chalk.)

1884.

Fox-Strangways, C.—Horizontal Sections of the Geological Survey. Sheet 139.

Mortimer, J. R.—A Description of the Origin and Distribution of the Unwater-worn Chalk-gravel on the Yorkshire Chalk Hills, supplemented by an account of neighbouring and somewhat contemporaneous Deposits. *Ibid.*, vol. viii., p. 287.

1885.

Reid, C.—The Geology of Holderness and the adjoining parts of Yorkshire and Lincolnshire. Memoirs of the Geological Survey. 8vo. *London.*

1886.

Cole, Rev. E. M.—Notes on the Geology of the Hull, Barnsley, and West Riding Junction Railway and Dock, p. 60. Frontispiece, five plates and map. 8vo. *Hull.*

———.—On some Sections at Cave and Drewton. *Proc. Geol. Soc. Yorkshire*, n.s., vol. ix., p. 49.

———.—On the Physical Geography and Geology of the East Riding of Yorkshire. *Ibid.*, p. 113.

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INDEX.

Acklam, 27.
Age of the Humber Peat, 38.
Alderson, Dr. J., 48.
Allison, T., 14, 17, 21, 24.
Alluvium, 38.
Analysis of Ironstone, 16.
  „ Limestone, 21.
Anticlinal axis, 40.
Area described, 1.
Atkinson, J. T., 49.

Band at the top of the Lower Chalk, 29.
Barlby and Riccall, Well between, 42.
Barmby on the Marsh, 43, 47.
  „ „ Moor, 8.
  „ Ridge, Well at, 5.
Barrois, C., 49.
"Basement Beds" of the Oolite, 19, 20.
Beaches ?, Raised, 34.
Bealsbeck, 37.
Bellasize, Well at, 9.
Beswick, 34.
Beverley, 2, 30.
  „ Park, Well at, 46.
Bilborough, 3.
Blake, Prof., 12, 21, 28, 30, 49.
  „ Messrs. Tate and, 14, 21, 32, 40, 49.
Blown Sand, 39.
Booth Ferry Road, Goole, Well at, 5.
Bones found at Bealsbeck and other places, 37, 38.
Boring near Brantingham Grange, 14.
  „ at Brough, 18.
  „ at Ellerton, 4.
  „ at Goole, 5, 6, 7.
  „ at Reedness, 7.
  „ at Saltmarshe, 7.
Boulder Clay, 31–33.
Brandsburton, 33.
Brantingham, 24, 29, 31.
  „ Dale, 29.
  „ Grange, 13, 14, 15, 18, 20, 21.
  „ Thorpe, 24.
Bray, W. B., 49.
Brayton Barf, 3.
Breccia, Chalk, 35.
Brecciated appearance of the Red Chalk, 27.
Bromfleet Carrs, Well at, 45.
  „ Landing, 45.
Brough, 17, 18, 20, 21, 22, 32.
  „ Scalp, 22.
Building stone from Brough, 21.
Bunter Sandstone, 3, 4.
Burn Park, 34.
Burnby, 8, 34.

Castle Farm, 15.
Cauldwell Spring, 14, 16.
Cave, 11, 21.
  „ Oolite, 20–22.
Cawood, Well at, 3.
Chalk, Middle and Upper, 30.
  „ Red and Lower, 29.
Chalk Gravel capping hills, 34.
  „ at Everthorpe, 33.
  „ at Kilnwick Percy, 32.
  „ at Pocklington, 38.
Chalk Wolds, 1, 12, 31, 33, 40.
Cherry Burton, 33.
Clarke, Mr., 7, 44.
Cleaving Grange, 13, 40.
Cliff, 13, 39.
Cliff Warren, Marl Pit at, 44.
Cole, Rev. E. M., 35, 47, 49, 50.
Colour of the Boulder Clay, 33.
Cottingham, Well at, 46.
Cretaceous Rocks, 27–30.

Dairy Cotes, Hull, Borings at, 46.
Denison's Wood, 13, 27.
Derwent River, 1, 4, 38.
Dogger, 19, 20.
Drainage of the Country, 1, 2.
Drewton, 22, 23, 28, 35.
  „ Beck, 16.
  „ Manor House, 23, 25, 28.
  „ Stray Cottage, Well at, 22, 24.
  „ Valley, 25.
Duffield, Well at, 42.

Eastrington, Well at, 43.
Elevation of the Country, 1, 40.
  „ „ Glacial Beds, 31, 33, 39.

Ellerker, 15, 16, 17, 19, 20, 21, 32.
Ellerton, 4.
Elloughton, 25, 26, 29, 32.
Escrick, 31.
„ Boring between Riccall and, 42.
Escrick House (Grange ?), 37.
Eskers, 33.
Estuarine Series, 19, 20.
Everthorpe, 15, 16, 20, 31, 33.

Faults, 40, 41.
Feature of the Middle Lias at Everthorpe, 33.
Ferriby, Wells at, 45.
Flint in the Chalk, Distribution of, 30.
Formations, Table of, 2.
Fossils of the Kellaways Rock, 23.
„ „ Middle Lias, 15.
„ „ Oxford Clay, 25.

George Street, Old Goole, Well at, 6.
Gjers, L. F., 16.
Glacial Beds, 31–33.
Gleadows Buildings, Goole, Well at, 5, 6.
Goodmanham, 13, 14, 28, 29, 41.
„ Lodge, 34.
Goole, 2, 5, 37.
Gravel, Glacial, 31–33.
„ of Dry Chalk Valleys, 34.
„ formed out of the Lower Lias, 13.
Graystones Chalk Pit, 29.
Great Oolite Clay, 22.
Grey Chalk, 29.
" Gruts," 35.
" Gryphite Gravel," 32.
Gypsum, 8, 9.

Harswell, Remains of Mammoth at, 38.
Healaugh, 3.
Height of the Glacial Beds, 31, 33, 39.
„ „ Ground, 1, 40.
Hessle, 33, 45.
Highcliff Plantation, 27.
Holderness, 1, 2, 30, 31, 33, 35.
Holme-on-Spalding-Moor, 8, 10, 31, 35, 40.
Hotham, 12, 15, 20.
Houghton, 12, 39.
„ Hall, 10, 13.
„ Moor, 13.
Howden Brickyard, 44.
Hull, 1, 2.
„ Boring near, 46.
„ River, 1.
Humber, 1, 12, 13, 19, 20, 22, 25, 29, 30, 31, 32, 35, 37, 38.
Humber, Boring in the, 46.
Hydraulic Limestone, 17, 19, 20.

Ironstone of the Middle Lias, 13–16.

Jukes-Browne, A. J., 29.
Junction of the Lower and Middle Chalk, 29.

Keeping, W., 50.
„ and C. S. Middlemiss, 15, 21, 23, 28, 50.
Kelfield Brickyard, Well at, 42.
Kellaways Rock, 22–25.
Kettlethorpe, 23, 28.
Keuper Marl, 8–10.
„ Sandstone, 4–8.
Kildwick Percy, 32.
„ „ Hall, 13, 27.
„ „ Park, 10.
„ „ Wold House, 14.
Kilnwick, 30.
Kimeridge Clay, 25, 26.
Kingston, R. C., 24.
Kirton Tunnel Quarry, Lincolnshire, 21.

Lair Hill, 33.
Landslip ? at Kildwick Percy, 32.
Leatham, J., 48.
Lias, Lower, 12, 13,
„ Middle, 13–16.
„ Upper, 16–18.
Lie of the Rocks, 40, 41.
Lincolnshire, Allusions to, 19, 20, 21, 22, 29.
Londesbrough, 27, 29, 40, 41.
„ Park, 10, 13.
Long Marston, 3.
Lower Chalk, 29.
„ Estuarine Series, 19, 20.
„ Lias, 12, 13.
„ Oolites, 19–22.
Lund, 33.

Man, older than peat of the Humber, 38, 45.
Marine shells in the Glacial Beds, 33.
Market Weighton, 2, 8, 10, 12, 13, 16, 19, 20, 21, 28, 31, 34, 37.
Marl pits, 9, 10, 12.
Marshall, W., 48.
Mask Hall, 21.
Melbourne, Well at, 9.
Melton, 32, 37, 38.
„ Bottom, 29.

Melton Creek Brickyard, 45.
Middle Chalk, 30.
,, Lias, 13–16.
,, and Upper Oolites, 22–26.
Middlemiss, Messrs. Keeping and, 15, 21, 23, 28, 50.
Middleton-on-the-Wolds, 33.
Mill Hill, 25.
Millepore or Cave Oolite, 20–22.
Mitchell, Dr. J., 48.
Morris, John, 50.
Mortimer, J. R, 28, 50.

Naburn Station, Well at, 3.
New Village, Well at, 44.
Newbald, 13, 15, 19, 20, 21, 23, 25.
,, Sike, 15, 16, 20, 28, 29.
Newton, 31.
North Cave, 13, 15, 31, 32, 39.
,, Cliff, 9, 10, 11, 12, 13, 37, 41.
,, Ferriby, Well at, 45.
,, Newbald, 23 28.
Norwood, Rev. T. W., 49.
Nunburnholme, 13, 14, 27.

"Old Chalk Pits" at Kildwick Percy, 32.
Oolites, Lower, 19–22.
,, Middle and Upper, 22–26.
Oolitic ironstone of the Middle Lias, 13–16.
Osgodby, Well at, 4.
Ouse River, 1, 5, 6, 7, 38.
Overlap of the Chalk, 12, 19, 20, 21, 22.
Oxford Clay, 25.
Oyster Ness, 25..

Park Farm, Londesbrough, 13, 28, 29.
Parsons, Dr. H. F., 3, 35, 42, 44, 49, 50.
Partridge Hall, 14, 16.
Peat, 35, 37, 38.
Pemberton's Brewery, Goole, Well at, 6.
Phillips, Prof., 26, 37, 48, 49.
Physical geography, 1.
,, structure, 40, 41.
Pink bands in the Chalk, 29.
Pocklington, 2, 8, 10, 12, 13, 31, 34, 38.
Pre-cretaceous anticlinal, 40.
Pre-glacial surface of the Trias, 37.

Railway Bridge, Goole, 5, 6, 7.
Red Chalk, 27–29.
,, Cliff, 32.
Reedness, 5, 6, 7.
Reid, C., 33, 50.
Rhætic Beds, 10, 11.
Riccall, Sections near, 42.
Ridges, Glacial, 31, 33.
River Bridge, M. W. Canal, 44.
,, Gravels ? Old, 34.
Routh, Well at, 46.

St. Austin's Stone, 35.
Salt, Pseudomorphous crystals of, 8.
Saltmarshe, 6, 7.
Sancton, 14, 15, 16, 19, 20, 21, 22, 28, 39.
Sancton Grange, Well at, 22.
Sand, Blown, 39.
,, Glacial, 31–33.
,, Hill, 24.
,, Pits, 22, 23, 24.
,, Warp, 35, 36, 37.
Sands of the Great Oolite, 22.
,, ,, Kellaways Rock, 23, 24.
Scorborough, 34.
Section in Chalk valley gravel, 34.
,, at Drewton, 23.
,, near Drewton Manor House, 28.
Section at Ellerker, 19.
,, near Ellerker, 17.
,, ,, Goodmanham, 14.
,, at North Cliff, 11.
,, ,, ,, Newbald, 23.
,, ,, the Railway Bridge, Goole, 6.
,, of Warp Beds, 36.
,, at Warter Brickyard, 27.
Selby, 2, 3, 4.
,, Waterworks, Well at, 4.
Shafts for Ironstone, Trial, 17, 24.
Shells in Chalk Gravel, Recent land-, 34.
,, Glacial Beds, 33.
Shipton, 8.
Skidby, 34.
Smith, W., 48.
South Cave, 13, 15, 20, 21, 22, 24, 32.
,, Cliff, 11.
,, Ferriby, 37.
,, Newbald, 21, 23, 29.
Springhead, Boring near, 46.
Staddlethorpe, 43.
Stamford Bridge, 4.
Stillingfleet, 36.
Strensall, 5.
Structure, Physical, 40, 41.
Subdivisions of the Chalk, 30.
Superficial Deposits, 31–39.

Table of Formations, 2.
Tate and Blake, Messrs., 14, 21, 32, 40, 49.
Temple Holes, near Holme, Well at, 44.

Terraces formed by the Lias, 12–15.
Terraces, Gravel, 34.
Thorp, Rev. W., 48.
Thickness of the Cave Oolite, 20, 21.
„ „ Chalk, 30.
„ „ Great Oolite Clay, 22.
„ „ Estuarine Beds, 19.
„ „ Hydraulic Limestone, 20.
„ „ Kellaways Rock, 22.
„ „ Lower Lias, 12.
„ „ Middle Lias, 13.
„ „ Red Chalk, 27.
„ „ Superficial Deposits, 35, 37.
„ „ Upper Lias, 16.
Thimble Hall Brickyard, 44.
Thinning of the Kellaways Rock, 24.
Trees found in the peat of the Humber, 38.
Trias, 3–10.
„ Level of the old surface of the, 37.

Unconformity of the Chalk, 12, 19, 20, 21, 22, 27, 28, 40.
Upper Chalk, 30.
„ Lias, 16–18.

Vale of York, 31, 35, 40.
Valleys, Chalk, 34.
Vernon, Rev. W., 48.
Villiers, Mr., 46.

Walling Fen, 47.
Walkington, 33.
Ward, J. C., 36.
Warp, Modern, 38.
„ and Lacustrine Clay, 35–37.
Warter, 12, 27, 29, 41.
„ Brickyard, 13, 14, 27.
Warter Priory, 10, 13.
Weedley Springs, 28, 29.
Well at Barmby Bridge, 5.
„ Bellasize, 9.
„ Cawood, 3.
„ Drewton Stray Cottage, 22.
„ Elloughton, 32.
„ George Street, Old Goole, 6.
„ Gleadow's Buildings, Goole, 6.
„ Holme-on-Spalding-Moor, 10.
„ Market Weighton, 10.
„ Melbourne, 9.
„ Naburn Station, 3.
„ Newbald Sike, 16.
„ Osgodby, 4.
„ Pemberton's Brewery, Goole, 6.
„ Sancton Grange, 22.
„ South Cave, 21.
„ Selby Waterworks, 4.
Well Sections, 42–46.
Welton, 25, 26, 29.
„ Cemetery, 45.
„ House, 29.
„ Springs, 29.
Whin Moor Lane, 17.
Whitton, 37.
Wilson, J., 22.
Wolds, 1, 12, 29, 30, 31, 33, 34, 40.
Wold Dale, 24.
„ valleys, Gravel in, 34.
Woo Dale or Woodale, 24, 25, 29, 32.
Wood, S. V., 49, 50.
„ House, 13, 27.

Yapham, 8.
York, 1, 2, 4, 31, 35.
„ Vale of, 31, 35, 40.

Zones of the Chalk, 30.

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Scale, one inch to a mile.

Anglesey, 78 (SW).
Bristol and Somerset, 19, 35.
Coalbrook Dale, 61 (NE & SE).
Clee Hill, 53 (NE, NW).
Flintshire and Denbighshire, 74 (NE & SE), 79 (NE, SE).
Derby and Yorkshire, 71 (NW, NE & SE), 82 (NW & SW), 81 (NE), 87 (NE, SE), 88 (SE).
Forest of Dean, 43 (SE & SW).
Forest of Wyre, 61 (SE), 55 (NE).
Lancashire, 80 (NW), 81 (NW), 89, 88 (SW, NW).
Leicestershire, 71 (SW), 63 (NW).
Northumberland & Durham, 103, 105, 106 (SE), 109 (SW, SE).
N. Staffordshire, 72 (NW), 72 (SW), 73 (NE), 80 (SE), 81 (SW).
S. Staffordshire, 54 (NW), 62 (SW).
Shrewsbury, 60 (NE), 61 (NW & SW).
South Wales, 36, 37, 38, 40, 41, 42 (SE, SW).
Warwickshire, 62 (NE SE), 63 (NW SW), 54 (NE), 53 (NW).
Yorkshire, 88 (NE, SE), 87 (SW), 92 (SE), 93 (SW).

GEOLOGICAL MAPS.

Scale, six inches to a mile.

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Lancashire.

Sheet.
15. Ireleth.
16. Ulverstone.
17. Cartmel.
22. Aldingham.
47. Clitheroe.
48. Colne.
49. Laneshaw Br.
55. Whalley.
56. Haggate.
57. Winewall.
61. Preston.
62. Balderstone.
63. Accrington.
64. Burnley.
65. Stiperden Moor.
39. Layland.
70. Blackburn.
71. Haslingden.
72. Cliviger, Bacup.

Sheet.
73. Todmorden.
77. Oherley.
78. Bolton-le-Moors.
79. Entwistle.
80. Tottington.
81. Wardle.
84. Ormskirk.
85. Standish.
86. Adlington.
87. Bolton-le-Moors.
88. Bury, Heywood.
89. Rochdale, &c.
92. Bickerstaffe.
93. Wigan.
94. West Houghton.
95. Radcliffe.
96. Middleton, Prestwich.

Sheet.
97. Oldham.
100. Knowsley.
101. Billinge.
102. Leigh, Lowton.
103. Ashley, Eccles.
104. Manchester, Salford.
105. Ashton-under-Lyne.
106. Liverpool.
107. Prescott,
108. St. Helen's.
109. Winwick.
111. Cheedale.
112. Stockport.
113. Part of Liverpool.

Durham.

1. Ryton.
2. Gateshead.
3. Jarrow.
4. S. Shields.
5. Greenside.

6. Winlaton.
7. Washington.
8. Sunderland.
9. ———
10. Edmondbyers.

11. Ehchester.
12. Tanteby.
13. Chester-le-St.
18. Hunstanworth.
17. Waskerley.

Durham—*continued.*

Sheet.
18. Muggleswick.
19. Lanchester.
20. Hetton-le-Hole.
22. Wear Head.
23. Eastgate.
24. Stanhope.

Sheet.
25. Wolsingham.
26. Brancepeth.
30. Benny Seat.
32. White Kirkley.
33. Hamsterley.
34. Whitworth.

Sheet.
38. Maize Beck.
41. Cockfield.
42. Bp. Auckland.
46. Hawksley Hill Ho.
52. Barnard Castle.
53. Winston.

Northumberland.

44. Rothbury.
45 Longframlington.
46. Broomhill.
47. Coquet Island.
54. Longhorsley.
55. Ulgham.
56. Druridge Bay.
83. Netherwitton.
64. Morpeth.
65. Newbiggin.
72. Bedlington.
73. Blyth.

80. Cramlington.
81. Earsdon.
82. NE. of Gilsland.
83. Coadley Gate.
87. Heddon.
88. Long Benton.
89. Tynemouth.
91. Greenhead.
92. Haltwhistle.
93. Haydon Bridge.
94. Hexham.
95. Corbridge.
98. Horsley.
97. Newcastle.

98. Walker.
101. Whitfield.
102. Allendale Town.
103. Slaley.
105. Newlands.
106. Blackpool Br.
107. Allendale.
108. Blanchland.
109. Shotleyfield.
110. Wellhope.
111. Allenheads.
112.

Cumberland.

55. Searness.
58. Skiddaw.
63. Thackthwaite.
64. Keswick.

65. Dockraye.
69. Buttermere.
70. Grange.
71. Helvellyn.

74. Wastwater.
75. Stonethwaite Fell.

Westmorland.

2. Tees Head.
6. Dufton Fell.

12. Patterdale.
18. Near Grasmere.

25. Grasmere.
38. Kendal.

Yorkshire.

7. Redcar.
9. ———
12. Bowes.
13. Wycliffe.
20. Lythe.
24. Kirkby Ravensworth.
25. Aldhorough.
32. Whitby.
33. ———
33. Marske.
39. Richmond.
46. ———
47. Robin Hood's Bay.
53. Downholme.
68. Leybourne.
82. Kidstones.
84. E. Witton.
97. Foxup.
98. Kirk Gill.
99. Haden Carr.
100. Lofthouse.
115. Arncliffe.

116. Conistone Moor.
133. Kirkby Malham.
184. Dale End.
185. Kildwick.
200. Keighley.
201. Bingley.
202. Calverley.
203. Seacroft.
204. Aberford.
215. Peeke Well.
216. Bradford.
217. Calverley.
218. Leeds.
219. Kippax.
231. Halifax.
232. Birstal.
233. East Ardsley.
234. Castleford.
246. Huddersfield.
247. Dewsbury.
248. Wakefield.
249. Pontefract.
250. Darrington.

260. Honley.
261. Kirkburton.
262. Darton.
263. Hemsworth.
264. Campsall.
272. Holmfirth.
273. Penistone.
274. Barnsley.
275. Darfield.
276. Brodsworth.
281. Langsell.
282. Wortley.
283. Wath upon Dearne.
284. Conisborough.
287. Low Bradford.
288. Ecclesfield.
289. Rotherham.
290. Braithwell.
293. Hallam Moors.
295. Handsworth.
298. Laughton-en-le-Morthen.
209. ———
300. Harthill

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